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The Sewerage of Algiers. By M. PIARRON DE MONDESIR, *Ing. des Ponts et Chaussées.*

(Continued from page 226.)

Man-hole Shafts.—These shafts, which served for the excavation of the tunneling of the branch Bab-Azoun, were, from the beginning, opened the clear width of the galleries with a length of 9·84 ft. measured along the axis of the sewer. It was found to be necessary to line them with masonry throughout their height to preserve and transform them into man-holes.

The cylindrical opening of the masonry of the man-hole shaft preserved the width of the gallery in the clear; its height was variable and its length was always 9·84 feet. The horizontal section presents a rectangle much rounded at the angles, a disposition chosen from simple motives of economy. The upper end is covered by a semi-circular arch, in which is placed a circular trap-door 1·96 ft. in diameter. This trap is closed by an assemblage of cut-stone bedded in the arch, and like those of the simple man-holes, supporting an oak frame and a cast iron frame. The position of the trap varies in each man-hole shaft for different local reasons, but it is always situated directly above the axis of the gallery, so as to utilize the opening in raising or lowering materials without injury to the landing places or the ladders. To effect an easy descent through the man-hole shafts, landing places

of cut-stone were established at different heights, and to them were fastened oak ladders tarred.

The upper landing is placed 4·9 ft. below the level of the revetment arch. It is approached by a small portable ladder. The lower landing is established at nearly half the height between the springing and the key of the main sewer arch. The lower ladder, resting upon the invert of the sewer, is hung upon the screw rings let in upon the lower landing, and may be raised at will by a chain and pulley placed upon the second landing. This disposition makes the access to the sewer through the man-hole shafts as easy as possible. These man-hole shafts are usually accompanied by a water inlet cess-pit, which is connected with it.

Water Inlet Sumphs.—These sumphs being only 1·97 ft. wide,* with depths from 29 to 39 ft., would have presented peculiar difficulties had they been isolated and dug out separately. Their connexion with the man-hole shafts, as might be expected, has greatly facilitated their construction, as it only called for a simple enlargement of the excavation. These sumphs are not only designed to receive the rain water of the grate surmounting them, but they serve for the general issue of all the neighboring sewers. In fact, its great depth did not admit of our multiplying direct branches upon the sewer itself. They have been united by lateral secondary sewers, and directed to the nearest sumph. There are sumphs receiving affluents upon their three sides. By reason of the great mass of water which they receive, and the formidable shocks to which they are exposed on account of their great depth, these sumphs are well provided with cut-stone bottoms and covered with a coating of Vassy cement. The top of each sumph is crowned like the common water inlets.

Different Connections.—It is seldom that each private dwelling is brought in direct communication with the main sewer. We were compelled to construct upon each branch a considerable development of lateral collecting sewers, which receives the drainage of a series of houses and then branches into the main sewer. I would observe that the affluent or lateral branches were always located so as to arrive in an oblique direction. A cut-stone sill, or overfall stone, is always placed at the outlet of an affluent into the sewer.

The terrace spouts were put in communication with the sewer, or its affluents, by means of small canals in masonry, much inclined. A small chimney covered with a flagging serves to cleanse the small conduit when choked up.

Projected Flushing.—It was held as a principle, by the Council General of "Ponts et Chaussées," and by the War Department, that flushing should be practised in the three branches, to operate a general cleansing. This part of the work is only projected. I give a summary account of it, as completing the works pertaining to the sewerage system of Algiers.

A reservoir containing 1757 cubic yards of water is projected under the public square of Chartres. The depth of the water in the reservoir

*An exception is made in the case of the ravine sewer of Tivoli, which has a width of 3·28 ft. and is connected with the man-hole shaft, T 12.

is to be 13 ft. The waste is established at the side, 72 ft. above the mean level of the sea. The reservoir is fed by the waters of the Hamma, that is to say, by the product of the conduits placed in the branch Bab-Azoun. The flushing conduit, whose level is at the level of the invert of the sewer, will be 0·98 ft. in diameter. It will pass through the streets Chartres and Porte-Neuve. Arriving at the right of the Arcades of Government Square, it forks on one side towards the head of the Bab-Azoun branch, and on the other, to that of the branch Bab-el-Oued. Opposite the street Divan, a branch at right angles is directed towards the head of the Marine branch. Gates are disposed so as to turn the water, at will, into either of the three branches.

The plan, as prepared and submitted to the Administration, has not provided galleries for the placing of the flushing pipe between the heads of the three branches. But this would be an ill-judged economy, and the establishment of these galleries would be so advantageous for the general ventilation of the sewer, that a change from the original plan will be proposed for this purpose, and will most probably be accepted. The length of the galleries to be opened between the three heads, will be 636 feet. This length will be reduced to 295 feet, if we limit ourselves to the communication between the heads Bab-Azoun and Bab-el-Oued.

It is readily conceived what a powerful means of ventilation will be gained by thus putting into communication the three branches of the sewer, or at least the two principal ones. We shall have, then, a single canal emptying from its summit into the sea at each end, and a very strong current, which will drive the gas towards it, on either side, according to the direction of the wind.

In note B, will be found calculations and observations relative to the effects of these flushings.

Workmen killed and wounded.—It is well known that subterranean works are dangerous for the workmen. Accidents would increase at every step, unless the greatest precautions were taken, and the most active supervision maintained by the Administration. Fortunately, we had but few accidents to regret, upon the works of the sewer. Two workmen only were killed, five were seriously injured, and seventeen slightly. One of the workmen was a victim to his own awkwardness in falling from the top of the ladder, in a man-hole shaft. Another was the victim of his own imprudence and disobedience of the engineer's order, in using an iron tamping-bar to charge a blast, instead of the prescribed one of copper. The wounds were mostly received in the subterranean galleries of Bab-Azoun. They were generally occasioned by the falling of the rocks. The government generously relieved the principal sufferers from accidents.

I cannot let this opportunity go by without bearing testimony to the unshaken devotion of the laborers employed on the sewerage works. A large number of excavators, miners, and masons, have been upon the work from its commencement to its completion, without refusing any task, however painful or dangerous. I have never seen these men leave their post in time of danger. I would also bear witness to the

good conduct of M. Gay, the Overseer, who supervised the works of the three branches most creditably in all respects.

Archæological Discoveries.—In the execution of the work, there were frequent deep diggings in variable soil. While, in the galleries of the Bab-Azoun, was found the virgin rock, the base of the site of Algiers; in the streets Bab-Azoun, Bab-el-Oued, and Marine, was frequently encountered made ground, and already worked, either by the Moors or Romans.

There was brought to light, in the Marine street, at depths from 13 to 16 ft., an ancient Roman Way, whose walls of hard cut-stone were used for pit-fall stones in the construction of the sewer. The inhabitants of Algiers must have seen a great number of these flags deposited in some of their streets. The rain had cleansed them, and in their worn and polished surfaces might be seen the traces of circulation interrupted many centuries back. Similar flaggings were found, but in less quantities, in the streets Bab-Azoun and Bab-el-Oued.

Upon all points where the ground occupied and traveled by the Romans has been laid bare, has been found a great number of medals. Also, at the extremity of the street Bab-el-Oued near Fort Neuf, were discovered articles of pottery, such as lamps, lachrymals, funeral urns, &c. The relics have been sent to the Museum of Algiers.

Results in a Sanitary point of view.—In its actual state, the harbor, freed from the product of a great majority of the waters which polluted it before, is not as yet thoroughly cleansed. Indeed, some of the constructions adjoining the sea, and especially many houses in the street of Are, in the quarter of the Marine, are found to be too low to turn their waters into the sewer. The port then receives a very small contingence of the filthy and impure water. But when the magnificent projected street, called Rempart, shall be completed, the port will be thoroughly cleansed.

This street will enclose the city on the port side, with a continuous girdle, and will form an upper quay built upon arches, and separated from the quays proper by an enormous breast-wall.

The establishment of this new street will of necessity occasion the disappearance of all the low structures which still empty into the port, and its levels being calculated to deliver all their water in the main sewer through transverse sewers already begun to be built, the harbor will not then receive a single drop of water coming from the city. It will only receive the waters of the islet of the Marine, and of some new quays, a surface for which no account has been taken in my calculations, as once before stated.

Expense.—It remains now to give the amount of expenditure.

The enclosure sewer of Algiers, comprising all the secondary canals and accessory works, such as the tram railroad, consols support for the water pipes and wiers, amounts to the sum of . .	$ 103,550·00*
The reservoir and flushing pipes, with communicating galleries, will cost	20,900·00
Total, .	$ 124,450·00

* Calling the 5 franc piece 94 cents.

I give now some mean prices resulting from the settlement of the accounts.

A running yard of the branch Bab-el-Oued, exclusive of man-holes, water-inlets, connexions, consols, &c., (mean price for the three sets of 3·93 ft., 4·26 ft., and 4·92 ft. of this branch,)	$ 14·86
Do. for the branch of the Marine (two sections, 2·3 ft. and 3·3 ft. wide),	10·10
Do. for the branch Bab-Azoun, partly in open cut, (two sections, 3·93 ft. and 4·9 ft. wide,)	14·35
Do. for the branch Bab-Azoun, subterranean part, (four sets, 5·9 ft., 6·2 ft., 6·56 ft., and 13·12 ft. wide,)	41·43
Mean price per running yard of secondary canals (their widths varying between 1·3 ft. and 4·26 ft., with flag coverings or brick arches),	4·03
Total expense of connexions relative to 110 private sewers, 69 gutters, and 24 urinals,	2,255·34
Mean price of one of these works,	11·10
Do. of a simple man-hole,	73·32
Do. of a shaft with sumph attached, (exclusive of excavation,)	282·18
Do. of a water-inlet with spare cast iron cover,	64·60
A running yard of tram railway, including the wagons,	9·40

All these prices should be increased 18 per cent. to allow for contingencies.

In terminating this article, I find I have gone farther than I intended at the commencement. It may, perhaps, be thought that I have allowed myself to be drawn into useless and uninteresting details. I accept the reproach at the outset. I make no pretensions here to anything new, either in the question of sanitary matters, or in the special art of constructing subterranean canals. My main purpose was simply to publish this extremely useful work which insured the health of a city and harbor, and which, in this regard, places the port of Algiers in an unquestioned superiority over that of many other ports, and especially that of Marseilles.

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NOTES ON THE PRECEDING MEMOIR.

NOTE A.—*Upon the increase in the delivery of the branch Bab-Azoun, resulting from the modification adopted in the execution of this work.*

(See the profile of the branch Bab-Azoun, Pl. II, Fig. 3.)

It will be seen upon the longitudinal profile between Scipio street and the sea, that the line of springing has followed exactly the uniform slope of the adjudged plan, which is not quite ·01 ft. per foot. The invert lowered successively 1·47 ft., 2·13 ft., and 2·78 ft., lies parallel to the springing line, except at the lower part of 479 ft., where the slope is reduced to ·005 ft. per foot.

Each section carries a different volume of water. We will admit that this volume is the same throughout the length of the section. This is not exact in practice, since the section receives affluents throughout its course. But, if we consider that the greater portion of the additional liquid of each section of 5·9 ft., 6·23 ft., and 6·56 ft., enters precisely at the origin of the three united sewers of the rampart Bab-Azoun, Poudriere, and of Tivoli, we may regard the assumption as admissible for calculations.

As the question is to ascertain the maximum volume each stream will deliver, without exceeding the level of the springing line, and as their respective lengths are sufficiently great to produce a uniform motion between the falls, it is unnecessary to take the falls into account in the calculations. Their effect cannot be construed but by a diminution in the height of the water above and below, that is to say, between the limits of uniform motion in the two consecutive sections. The force of impulse of the falls will yet be in part counteracted by the shock of the water of the three ravine sewers.

We will suppose that the slope of the sections is exactly ·01 ft. per foot. This granted we will calculate the velocity by the reduced formula $v=51\sqrt{p\frac{s}{c}}$ in units of metres, $v=53{\cdot}33\sqrt{p\frac{s}{c}}$ in units of yds. p is the slope, s the section, and c the wetted perimeter. This formula becomes for the case where the slope is ·01 ft., $v = 5{\cdot}333\sqrt{\frac{s}{c}}$ in yards.

It gives, for the section of	1·64 yds.,	$v = 3{\cdot}66$ yds.
"	1·97	$v = 4{\cdot}16$
"	2·08	$v = 4{\cdot}34$
"	2·19	$v = 4{\cdot}49$

It gives for the volumes delivered without surpassing the limits of the springing line,

	yds.	cub. yds. per sec.
For the section of	1 64	6·55
"	1·97	12·97
"	2·08	16·23
"	2·19	19·89

We must now compare these deliveries with the products of a storm of 0·16 ft. for the basins answering to each section.*

These basins are as follow:

Section of	1·64 yds.,	56·8 acres.
"	1 97	108·0
"	2 08	197·0
"	2·19	279·0

The section of 13·12 ft. does not deliver above that of 6 56 ft., other than the product of the Fort Bab-Azoun sewer. We must, then, consider the whole product of the Bab-Azoun basin as passing through the section of 6·56 ft; it is for this reason that we have taken the 279 acres as belonging to this section.

The products of a storm of 0 16 ft. answering to the above areas, are as follow:

	yds.	cub. yds. per sec.
Basin of the section	1·64	4·17
"	1·97	7·99
"	2 08	14·53
"	2·19	20·53

These results show that the whole of the rain fall can be passed through the deepened sections of the Bab-Azoun branch without getting above the springing line.

The section of 6·56 ft. is that in which the water will reach its maximum depth; but we would observe that the conduit pipes only begin at the shaft T 14, and that the last 406 ft. of the section is wholly without these pipes.

It remains now to ascertain whether the whole volume of 20·53 cub. yds. per second, can pass through the section of 13·12 ft., whose slope is but ·005 ft. per foot. Though this portion has only a length of 479 ft., and though it is found between the inclined plane at the outlet of the sewer into the sea, and the sudden change in the condition of flow arising from the doubling of the section, we may still admit that a uniform motion will be established for a certain length upon the middle of the section. Admitting this, we proceed by trial to find the height of the water in the part where the uniform motion is established.

Supposing this height to be 4·59 ft., and taking account of the railroad causeway, in calculating the value of $\frac{s}{c}$, we find for the discharge of the 13·12 ft. section, 19·73 cub. yds. per second. It is then demonstrated that the whole volume of the storm of 0·16 ft. per hour, after passing through the deepened sections, will also pass through the enlarged section of 13·12 ft., without sensibly surpassing the level of the springing line.

* The storm of 0·164 ft. per hour, adopted here as the basis of the calculations, may be considered as a maximum but rarely produced. For ten years, the rain gauge operations of M. Engineer-in-Chief Dom. have given for the maximum a fall of 0·16 ft., in 1 hour 30 minutes, which corresponds with a height of 0·108 ft. per hour.

Applying now the calculations to the original plan for the last section of 6·56 ft., we find that the whole discharge was restricted to 9·43 cub. yds. per second, with the condition of not exceeding the level of the springing line between T 14, and the ravine sewer of Tivoli; a discharge answering to the yield of a storm of ·075 ft. per hour.

The change has thus more than doubled the discharge of the branch Bab-Azoun. The wiers designed to be sometimes used in the system of the original project, will probably never be called into action, in that of the plan since modified and executed.

NOTE B.—*Effect of the proposed flushings in the sewer.*

We first present the elements of the calculations.

1. Branch Bab-Azoun.

	Feet.
Ordinate of the overfall of the reservoir,	72·00
" of the invert,	59·00
" of the inlet or centre of pipe at the head,	59·53
Height of water in the reservoir,	13·12
	Cub. yds.
Volume of the reservoir,	1758·00
	Feet.
Ordinate of the invert at head of branch,	52·48
" of centre of flushing pipe at its discharge in sewer,	52·97
Length of conduit,	361·00
Head on conduit,	19·03

2. Branch Bab-el-Oued.

The elements are the same except the following:

	Feet.
Ordinate of invert at head of branch,	53·98
" of centre of flushing pipe at its discharge in sewer,	54·48
Length of conduit,	584·00
Head on conduit,	17·14

3. Branch of the Marine.

The elements are the same except the following:

	Feet.
Ordinate of invert at head of branch,	47·79
" of centre of flushing pipe at its discharge in sewer,	48·28
Length of conduit,	869·00
Head on conduit,	23·87

The initial velocity of the flushing, or that of its discharge in sewer, if the reservoir remains constantly full, by Prony's formula (Genieys, page 153), will be,

	Feet.
At the head of the branch Bab-Azoun,	11·15
" " Bab-el-Oued,	8·36
" " Marine,	7·87

The section of the flushing pipe being equal to 0·772 sq. ft., the flushing will deliver the following quantities per second in each of the three branches:

	Imp. galls.
In the branch Bab-Azoun,	53
" Bab-el-Oued,	39·6
" Marine,	37·4

To ascertain the time of flushing in each branch, we will suppose the quantity issuing from the reservoir equal to 1700 cub. yds. only, and admit that it receives no supplies during the flushing. It is well known that the time required to empty a prismatic basin is double what would be needed to discharge all its waters, were the head to remain the same as at the commencement of the discharge. On this basis, the time of flushing in each branch would be:

	hrs.	min.	sec.
In the branch Bab-Azoun,	3	0	28
" Bab-el-Oued,	4	0	44
" Marine,	4	14	51

It is apparent that these flushings will be useless in the winter, for the least storm

will introduce into the main sewer quantities far above those just calculated, especially in the branch Bab-Azoun. But the flushing will have a great effect in hot weather and times of low water.

We may have an idea of this by comparing the delivery of the three branches with the quantity introduced by the flushing. I have not as yet gauged the quantity passed in sewer during the low stage, but it may be approximately calculated as follows:

The volume entering the city in summer is about 3924 cub. yds. for twenty-four hours, or, say, 7·7 Imp. galls. per second. We may admit that the loss from consumption, evaporation, &c., is compensated by the quantity derived from wells and cisterns, and adopt 7·7 galls. as representing the combined delivery of all the sewers of Algiers, in the low stage.

To make a just distribution of these 7·7 galls. among the three sewers, we must take as a basis not the general basins of each branch, but only the inhabited portion of each basin, for the uninhabited portions do not feed the sewers, since there are no rains, and because the ravines are dry at that time. Taking the inhabited parts of the basins, we have the following approximate surfaces:

	Acres.
Branch Bab-Azoun, ...	88·9
" Bab el-Oued, ...	44·4
" Marine, ...	14·8
Sewer emptying directly outside of port, .	14·8
	162·9

Dividing the 7·7 galls proportionately to these surfaces, we have for the delivery of each branch in the low stage, the following quantities per second:

	Cub. yds.
Branch Bab-Azoun, ...	272
" Bab-el-Oued, ...	179
" Marine, ...	64

During the flushing, these volumes will be each increased by 1700 cub. yds.; that is to say, that during this time, the volume of the branch Bab-Azoun will be multiplied by 7·25; that of the branch Bab-el-Oued, by 10·50; and that of the branch Marine, by 27·50. These results prove the advantage of flushing in hot weather.

It will be well to reduce the period of flushing in the branches Bab-el-Oued and Marine, or what is equivalent, to flush more frequently in the branch Bab-Azoun.

For the Journal of the Franklin Institute.

Upon Balancing Horizontal Direct-acting Screw Engines.

By Alban C. Stimers.

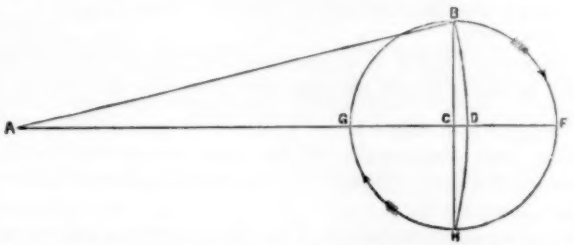
Great attention has been paid by engineers during the past few years to the subject of properly balancing *horizontal direct-acting screw engines.* The parts considered necessary to be balanced in this description of engine, are those which tend by their gravity to depress the crank-pin when the piston is at either end of its stroke, and, ordinarily, this is equal to the weight of the crank-pin, half the weight of the connecting-rod, and half the weight of the two cranks.

The practice of engineers has not materially differed about the *amount* of counter-balance which is required in each case, it being usual to apply sufficient weight upon the side of the shaft directly opposite the cranks to prevent the engine, when in a state of rest, having any tendency to move in either direction when the piston is at the end of the stroke. The improvements which have been made, have been in placing this counter-balance in the most favorable position.

The object of this paper is to show that an engine perfectly balanced

when in a state of rest is not balanced when in motion, and that if it is run in one direction the weight of the usual counter-balance is too great, while if it is run in the other, it is not sufficient.

Let A B, in the following diagram, represent the connecting-rod of a steam engine, of which B C is the crank and B F G the circle in which the crank-pin moves. The diameter of this circle, or G F, represents the stroke of the piston.



Now, if from the centre, A, and the radius, A B, equal to the length of the connecting-rod, the arc B D H is described; the point D will represent the position of the piston in the stroke G F, when the crank is in the vertical position, C B. This, it will be observed, is at a sensible distance from the middle of the stroke C, and if the engine is put in motion in the direction of the arrows, the half revolution, B F H, is made by a movement of the piston equal to 2 D F, and the other half revolution H G B by a movement of the piston equal to 2 D G, and as the times and piston pressures are equal during each of these half revolutions, the piston power available to drive the crank-pin from its highest to its lowest position, is less than that available to drive it from the lowest to the highest by 4 C D multiplied into the pressure transmitted from the piston to the crank-pin; and to remove this irregularity in the powers of the two half revolutions, it is necessary to have a preponderance at the crank-pin, which may be determined in any given case by the following formula:

$$w = \frac{p \times 2\,\mathrm{C\,D}}{s}$$

where w = the preponderance required at the crank-pin, p = the total effective piston pressure, and s = the stroke of piston. Because $p \times 2$ C D is the amount of power which must be deducted from one-half revolution and added to the other, and if this power is obtained by adding unbalanced weight to the crank-pin, it is manifest that this weight moves through a perpendicular distance equal to the stroke of the piston, and the foot-pounds to be overcome, divided by the feet through which the weight acts, gives the number of pounds necessary.

To show that this quantity is not an insignificant one, we will take the case of the U. S. Frigate *Merrimack*, of which I happen to have the necessary data.

It may, with propriety, be premised that the connecting-rods, &c., of the engines of this vessel were above the average in weight compared to diameter of cylinder and length of stroke; that the piston pressure

was less than usual; and that the ratio of length of connecting-rod to length of stroke was fully equal to the average.

There were two horizontal back-action engines connected direct to the screw shaft.

Diameter of cylinder,	72 inches.
Stroke of piston,	3 feet.
Length of connecting-rod,	7½ "
Mean effective pressure per square inch on the piston, being the average of more than 200 indicator diagrams taken during the year 1859,	10·23 lbs.

From the above length of connecting-rod and stroke of piston, the distance C D is easily found by first obtaining the base A C of the right angled triangle A C B, which is $(\sqrt{7{\cdot}5^2 - 1{\cdot}5^2} =)$ 7·34847, and then deducting this from the length of the connecting-rod, or A C, and we have (7·5 − 7·34847 =) 0·15153 as the value in feet of C D in the engines of the *Merrimack*.

From the mean effective pressure on the piston as given above, should be deducted that which is required to overcome the friction of the piston, piston rods, crosshead guides, and connecting-rod bearings; and as the air pump pistons are connected directly with the steam pistons by a rod passing through two stuffing boxes, there is the friction of the pump piston and piston rod, and the direct pressure upon the pump piston. This last was often obtained by means of indicator diagrams from the pumps themselves, and the usual average was 8 per cent. of the total effective pressure on the steam piston. It amounted, therefore, to (10·23 × ·08 =) 0·8184 lbs. per square inch of the steam piston, which, deducted from the total, leaves (10·23 − 0·8184 =) 9·41 lbs., and if we assume that 1·41 lbs. per square inch of the steam piston pressure will overcome the loaded friction of the parts above enumerated, we shall probably not err much. This leaves 8 lbs. per square inch transmitted to the crank-pin, and to obtain the value of p in the foregoing formula the area of the piston must be multiplied by this amount. The area of a piston 72 inches diameter is 4071·5 square inches, therefore $p = 4071{\cdot}5 \times 8 = 32572$ lbs., and as $s = 3$, we have

$$w = \frac{32572 \times 2 \times 0{\cdot}15153}{3} = 3290 \text{ lbs.}$$

This is the preponderance which it is necessary there should exist at the crank-pin of the *Merrimack's* engines, to maintain them in a perfectly balanced state when running in the direction marked by the arrows of the foregoing diagram.

To determine now how much counterbalance there should be for running them in the direction shown, it is necessary to ascertain how much preponderance there is at the crank-pin without any balance.

The following are the weights which tend to depress the crank-pin when the piston is at the end of the stroke.

Half of one connecting-rod, complete,	1950 lbs.
Half of two cranks,	1315 "
One crank-pin,	485 "
Total,	3750 "

The counterbalance required, then, upon the side of the shaft directly opposite the cranks, and at the same distance from its centre as the crank-pin, is (3750 − 3290 =) 460 lbs.

By a similar process of reasoning, it may be shown that if the engine is run in a direction contrary to that marked by the arrows, the preponderance, instead of being required at the crank-pin, must be placed on the opposite side, and that in the case of the engines of the *Merrimack*, the counterbalance would require to be (3750 + 3290 =) 7040 lbs.

It so happens that the position of the two engines of this vessel is such that while the forward one runs in the direction shown by the arrows of the diagram, when the vessel is being driven ahead, the after one runs in the contrary direction.

The counterbalance for both engines is in one piece, and is placed, not only abaft the engines, but upon the after part of the loose coupling connecting the line of shafting, running out through the stern to the screw, with the crank shaft.

On account of its great distance from the forward engine it probably had very little influence upon it, and it is worthy of remark in this connection that this engine always worked much more smoothly and regularly than the after one.

It is quite the common practice now to run the engines of our screw steamers in the direction contrary to that shown by the arrows in the diagram, because the oblique action of the connecting-rod upon the crosshead guides is upward when running in this direction, whereas, when running the other way, this action is downward, the friction in the latter case being the oblique force of the rod *plus* the weight at the crosshead, and in the other direction the friction is only the *difference* between these quantities.

The engines of the *Merrimack* afford an excellent opportunity to judge of the importance of this subject, the oblique force of the connecting-rod pressing down upon the forward crosshead at the same time that it lifts the after one, and if the fears of constructing engineers were well founded, the former would heat and give trouble, while the latter would work to a charm. The reverse of this, however, was the case in fact. It was the forward crosshead that never gave trouble, while the after one required frequent attention, as it was important that there should be as little play in the guides as possible, because when a few inches of the stroke had been performed, the lifting force of the connecting-rod became sufficient to raise the crosshead against the upper guide, and when it arrived at a corresponding distance from the other end of the stroke, it would drop again to the lower slide, and it may easily be imagined that when heavy engines like those under consideration were making forty or fifty revolutions per minute, this lifting and dropping process was not a very gentle affair. The only way in which the blow could be softened was to make the distance through which the crosshead rose and fell as small as possible, and sometimes this would be reduced a trifle too much, and heating ensue as a natural consequence. Whereas the forward crosshead

always worked perfectly smooth and never gave the slightest trouble from heating or any other cause.

It appears preferable, therefore, to run the engines in the direction of the arrows for reasons entirely independent of any consideration of the counter-balance, and when to this is added the great convenience of having the engine balanced without the application of any counterbalance whatever, there should certainly be very little hesitation about it.

That to apply no counter-balance would be the proper course to pursue, is evident from an examination of the case of the *Merrimack*, which we have taken as an example, for it would only have required an increase of steam pressure upon the piston of 1¼ lbs. to have caused the engines to run in a perfectly balanced state, supposing them to be run in the direction of the arrows, and if the pressure was still more increased, there would require to be weight added to the crank-pin to maintain the balance perfect, but even in engines carrying much higher steam than those of the *Merrimack*, engineers would very properly hesitate to do this on account of the great irregularity with which the engines would run when reversed.

Steam Engineering in 1859.* *Recapitulation.*

Concluding Remarks.

The first paper of this series appeared in the May number, and was intended to point out the avoidable difference existing between the present practice of steam engineering, and that which, if generally adopted, would result in many and undoubtable advantages.

It was intended also to indicate that steam engineers were practically neglecting to appreciate the only true principles in steam engineering, on which all economy must rest, and that with few exceptions, we are literally wasting money and time by allowing the manufacture of steam engines to degenerate into a mere trade.

During the past six months, several instances have occurred, in which the possibility of an indicated horse power being obtained from the consumption of 2½ lbs. of coal, has been more than verified, and these instances have, in many particulars, confirmed fully the truth of all we have stated in reference to the economy of steam power.

Paddle engines of considerable power are now regularly working with a consumption less than 2½ lbs. of coal per hour, and this is accomplished with all the disadvantages arising from the use of salt water. This creditable result is due, solely, to an intelligent appreciation, by the designer, of those truthful principles we have endeavored to recommend.

In another case of recent improvements in steam power, by an improved class of boiler, the use of distilled water, conservation of heat, and extensive development of the expansive principle, an indicated horse power has been realized by a consumption considerably less than 2 lbs. of coal per indicated horse power per hour.

* From the Lond. Artizan, Dec., 1859.

In another case, with more limited expansion and pure water for evaporation, the coal consumption has averaged for a considerable period less than 2½ lbs. per indicated horse power per hour.

The above cases in actual practice, are well authenticated, but it is unnecessary to remind the practical reader, that, in the application of steam power, many conditions have to be fulfilled besides that of economizing fuel; cost of construction, simplicity, safety, weight, space, durability, have all to be separately considered; and the greater the change introduced, the longer the time required to test it before it deserves the confidence of the public.

To insure the acceptance of our statements, even by those most indisposed to wander from the beaten track, in all cases we have stated *less* than the truth; that is, present defects have been leniently represented, and the advantage that may be obtained from attention to true principles of economy, has been underrated.

It must not be forgotten that the success of improvements, and more especially their general adoption, are greatly dependent on the moderation of the engineer who introduces them; many a fair and useful change has been kept in abeyance for years, by a want of moderation and judgment in the inventor. Experience teaches us that it requires more judgment to decide how and when to introduce an improvement, than it does to decide on the merits of the improvement itself.

In marine engineering, safety and the greatest possible freedom from risk must be secured, even, if necessary, at the cost of economy; and whoever introduces changes of a radical kind, incurs a heavy responsibility, and may, by a want of prudence, be a curse to his patrons and the profession; but this somewhat severe caution need not disturb or check the honest and earnest inventor; his success is certain, if he is moderate and *progressive*.

There are many good practical engineers and mechanics, but few practical philosophers—we polish the shell but waste the kernel. When shall we estimate the efficiency of a steam engine by the difference existing between heat expended and heat utilized? When shall we appreciate the vitality and importance of the true principles of economy, as distinct from mechanical construction? When shall we cease to sacrifice solid advantages to apathy, ignorance, and trade puffery?

In the June number, the generation of steam was considered, and we trust our readers will excuse our requesting particular attention to the statements made on that subject.

Statistics embracing a large field of observation have lately been published, giving accurate information on the duty and economy of the Lancashire engines and boilers, and we have the satisfaction of knowing that these statistics have most fully confirmed our own estimates, a matter of no slight importance, when it is remembered that present duty must form the basis from which all improvements spring.

A steam *engine* is attractive to the young steam engineer, but what does he care about the dirty black looking *boiler?* As a general rule (comparatively) he never takes any interest in boiler construction until he is thrown on his own resources, when he is compelled to do so to

maintain his credit and position; there are now hundreds of engineers holding important and responsible positions, in positive ignorance of the laws that determine the economical efficiency of a steam boiler—dogmatism takes the place of knowledge, and we pick the fruit of such a state of things in wholesale waste.

Perfect combustion is the starting point in steam generation, and thanks to the perseverance of some, earnest in their adherence to first principles, there is a prospect of great improvement in the furnace arrangements of steam boilers; but it is extraordinary what time it takes to convince engineers that it is impossible to obtain a sufficient supply of air through the grate bars; or that perfect combustion is not attainable except at a very high temperature; and that space should be given to allow the air and gases to combine.

The conversion of coal and air into an equivalent of heat must be the first process—and then, as the second process, that heat can be applied with full effect—but the custom is, by low furnaces and contracted combustion chambers, to begin the second process before the first is half completed, the result being a certain loss.

With brick furnaces a much less space for combination and combustion is sufficient, as the furnace case approaches in temperature that of the furnace itself; but with furnaces inside a steam boiler it is quite different—the plates surrounding the fuel are always at a low temperature compared with that of combustion, and will, if in too close contact with the fuel, absolutely prevent the necessary temperature for perfect combustion ever being attained.

This is so self-evident that the present faulty construction of boiler furnace is quite unaccountable.

In the boilers of the *Great Eastern*, it is quite evident that they were designed in improved accordance with the right principles of construction we have alluded to—the combustion space being in excess of the general practice.

In the June and July numbers, we pointed out the characteristics of the wasteful and economical generation of steam, and as they are more neglected than any other connected with boiler construction, we must yet add a few more statements in illustration.

It must be allowed as undisputed that with an average rate of combustion and a given class of boiler, a certain amount of heat absorbing surface must be given to take up the heat generated in the furnace, minus what is required for draft in the uptake—if this surface is not given, a certain amount of the heat is transferred from the water to the chimney.

Referring to the tables of ratios in the June number, we find experience fully confirms the fact stated above; and it will be found without a single exception, *other points of construction being similar*, the evaporative duty obtained from a pound of coal is always proportionate to the ratio between the heating surface and the rate of combustion, a large ratio increasing, and a small ratio decreasing that duty.

It is matter of sincere regret that we have to select as one of the most striking cases of a neglect of the above undeviating principle of economy, the boilers of the *Great Eastern*.

In February, 1855, the late Mr. Brunel reported to the proprietors of the great ship, that much attention had been paid to economy of fuel in the design of the boilers, and that, to prevent a chance of error, an experimental boiler had been made. After such a report it might have been expected that a maximum evaporation would be obtained from the coal.

At pages 137 and 138, are given two experiments of evaporative duty in boilers of similar construction to those in the *Great Eastern*, except as to the ratio of heating surface to rate of combustion, which was, in the first case, 0·83 to 1, and in the second, 1·9 to 1. The difference of evaporative duty in these boilers was nearly 40 per cent.

In the boilers of the *Great Eastern* there are only some 20 square feet of heat absorbing surface to one square foot of fire grate, and with 100 ft. height of chimney, and a high temperature in the uptake, there is every reason to believe, the furnace, when fully supplied, would consume *at least* 20 lbs. of coal per square foot of fire grate, or 430 tons per day, and with dampers fully open, it is difficult to believe that less than 24 or 25 lbs. of coal were burnt per square foot of fire grate. No practical man, who has well considered the subject, can accept the statement, that when working the boilers at their full steaming power, the consumption of coal was only 309 tons a day, or 14 lbs. per square foot of fire grate.

It is no matter of surprise that the water jacket became a second boiler, for it is quite certain, with the deficient heating surface a high wasteful temperature in the uptake is inevitable.

The remedy in the case of the *Great Eastern* is to take away at least one-third of the grate surface, and adopt some plan for preventing the loss arising from condensation in the cylinder—the result of such alteration would be a considerable decrease of the coal consumption and a considerable increase in the power of the engines and the speed of the ship.

In steam generation it is simply a matter of *choice* with the steam engineer as to what evaporative duty (within certain limits) he obtains from the fuel—shall it be 6, 7, 8, 9, 10, or 11 lbs. of water evaporated by a pound of coal? He can obtain either result without any radical change in the construction or form of boiler.

Before leaving the subject of steam generation, we must once more revert to the defective circulation of the water in marine and locomotive boilers. It is somewhat difficult to estimate the amount of loss incurred by deficient circulation, but there is no difficulty in proving that a considerable loss of evaporation is incurred, and also that another certain evil results—namely, premature destruction of the conducting metal.

In the August number, "the application of steam as a motive power" was considered, and the importance of maintaining the temperature of the steam in its passage to and through the engine, and of avoiding all premature condensation, was strongly represented.

The economy to be derived from the steam case or jacket round the cylinder is still disputed, but it is strange that the bulk of the objectors to the jacket have, in no case, made a fair comparison of economy

by dynamometer or indicator, with and without the jacket. Cornish engineers object on account of the piston packing being affected by the heat given out by the jacket. To remedy this, the jacket was removed, and "they never noticed any increased consumption of coal." Most scientific conclusion, truly!!

In addition to the cases already given of economy derived from the application of steam jackets, we may add two more. In each case the experiments were carefully made with and without the jacket. In the first case a saving of 27 per cent. was realized with the jacket, and the water condensed in it was less than 5 per cent. of the total quantity evaporated.

In the second case the saving was 22 per cent. with the jacket. The water condensed in it not being ascertained.

There are two points worth consideration in estimating the economy to be derived from steam jackets in condensing engines. The first is, that there is condensation only, and no re-evaporation in the jacket as in the cylinder. And secondly, that during half of each stroke the condensation in the jacket is practically uniform at all rates of expansion. It must also be borne in mind the re-evaporation that takes place during the exhaust stroke in the cylinder, not only robs heat from it, but requires increased duty from the condenser.

Superheated steam with an old boiler is often an evidence of original defective construction, but applied to a well designed new boiler it has advantages difficult to obtain in any other way. Any plan by which a greater amount of useful effect can be derived from the heat generated in the furnace, is a step in the right direction, and time and experience alone will prove what effect the highly heated steam has upon the working valve and cylinder surfaces.

There is a striking similarity in the amount of economy derived from the use of steam jackets and that of superheated steam.

Without expansion, 40 lbs. weight of steam will give an indicated horse power; with an expansion of three times, or cut off at one-fourth the stroke, 18 lbs. weight of steam will give an indicated horse power, making no allowance for leakage or condensation. Supposing steam jackets applied, and allowing one-fifth for condensation, leakage, &c., and assuming 10 lbs. of water to be evaporated by one pound of coal, and the steam to be expanded three times, *practically* an indicated horse power can be obtained by the consumption of $2\frac{1}{4}$ lbs. of coal, just one-half of the present average consumption, and this result can be realized without any great change in engine or boiler construction; and be it remembered when this improvement has been effected, we have only *began* to economize. As a commencement, an average of $2\frac{1}{2}$ lbs. of coal to the indicated horse power will be acceptable, and when that is accomplished, we shall find many pioneers doing the same duty with one pound.

As the indicator does not give us the power absorbed in friction, in and beyond the machine, it is impossible to use it in comparing the efficiency of two engines of a different class; for instance, a compound or Woolf engine having the same indicated power and consumption of

coal as a single cylinder engine, would necessarily be the least efficient of the two from the increased friction.

The indicated power of the "*Great Eastern's*" engines has been published as 7600 when working full power, and consuming 300 tons of coal per day; this gives $3\frac{3}{4}$ lbs. of coal per indicated horse power per hour; but for reasons we have given as to the evaporative duty of the boilers, and from the limited expansion employed, it is to be feared that at least $4\frac{3}{4}$ or 5 lbs. are required per indicated horse power per hour; a most unsatisfactory result.

In some experiments with engines and boilers similar in proportion to those in the "*Great Eastern*," $4\frac{3}{4}$ lbs. of coal were consumed per indicated horse power per hour, working under favorable circumstances; and from the class of engines adopted for the screw, a less favorable result even than that referred to, must be expected from them.

It may be taken for granted that if there had been sufficient boiler power in the "*Great Eastern*" to indicate the anticipated 10,000 actual horse power, at least 500 tons of coal would have been consumed per day.

Notwithstanding the adoption, by an eminent firm, of trunk engines for screw propulsion, as simple and compact in a mechanical point of view, they are, by their very construction and the cooling surface exposed, inadmissible as economical engines; and when we practically recognise the truth, that economy of fuel is the great desideratum, this description of engine will be as neglected as it deserves to be. For naval purposes, horizontal engines with double piston rods are almost equally compact with the trunk, and can be worked with very much less waste of fuel.

Reformation always springs from the people; as in politics and religion, so in science, those high in professional position are too often only the remote followers, and not, nay never, the pioneers, or even the encouragers of improvements.

To which of our great engineering firms is steam engineering indebted for a due attention to economical principles of construction? Do they not in daily practice ignore the existence of power in heat?

Strange, but most true is it, that the highest price is often given for steam machinery, in the arrangement of which there has been the least attention paid to economical efficiency.

We are loth to believe that the value of a steam engine is to be regulated solely by the excellence of its mechanism and workmanship.

It is quite certain that our government, through its engineering officials, has been instrumental, to an alarming extent, in repressing improvement, and encouraging the "let alone" system in the steam machinery of the navy.

A few fortunate inventors, by (to them) an age of perseverance and a determination not to be discouraged by any amount of official ignorance and red tapeism, have succeeded in obtaining a fair trial of their inventions; but most men who have matured improvements, will not subject themselves to the uncertainty of governmental patronage.

For instance, if an engineer succeeds in reducing the present con-

sumption of fuel by some well proved improvements on boilers or engines, he dare not submit his plans to the Admiralty, because he knows too well the jury will have to give the verdict; and if the great contracting firms who supply Government with marine engines of the old wasteful type, should disapprove his new plans, where is there a court of appeal? He is forewarned by the experience of others, that the chances are one hundred to one against him.

Better days may, and they assuredly will, come, when all who are competent will be allowed to compete for Government orders, and at the present moment the list of privileged firms is being wisely extended.

It would be difficult to estimate the advantage to the country of offering a premium for the best arrangement of steam machinery for the gunboats; they are used in a service that requires them to have the following qualifications: *First*, to be easily concealed from the sight or hearing of the enemy; *Secondly*, to go the greatest distance with the least weight of fuel; *Thirdly*, to require a minimum amount of repair; and, *Fourthly*, to be able to raise steam at the shortest notice: these are the requirements of the service they are built for. How are they fulfilled?

1. They have a puff blast in the chimney to attract the sight and hearing of the enemy.

2. They are wasteful on fuel and go the least possible distance with a maximum consumption.

3. They require more decided, extensive, and constant repair than any other class of machinery in Her Majesty's Steam Navy, and

4. From two to three hours are required to raise the steam.

Never surely, was there a more striking instance of success in trying "how not to do it."

There is no difficulty whatever by simple and inexpensive alteration in the gunboat boilers and engines, in getting rid of the steam blast in the chimney; reducing the consumption of fuel one-half, to accomplish the same distance as before, or in other words to propel the boats twice the distance for the same amount of fuel; supplying the boilers with pure water, thus avoiding the heavy repairs rendered necessary by the use of salt water in small boilers that cannot be cleaned; and lastly, raising the steam in one-fourth the time required at present.

To those entering the field of steam engineering, we would say, despise no man's opinion or experience—hear all you can, but be careful what you retain for use—those engineers who have been noted for their disrespect and contempt for the opinions of others, are always those who have much the greatest blunders in their own practice.

Successful engineering consists greatly in a wise selection from an extensive experience, and not from that alone of one individual, which is necessarily partial and limited.

In the design and construction of steam engines, the manufacturer is seldom in a position to keep pace with the requirements of the users of steam power, and in proposing changes of construction, tending to economize, he has some difficulty in obtaining compensation for additional cost in increasing the duty realized from a given amount of fuel.

If in the construction of railways it was found necessary to introduce

a professional man between the proprietor and the contractor, it is still more necessary in the construction of steam machinery, if it is wished to have that machinery designed on the best principles.

At the same time, however, we fear steam engineers of the ability and judgment necessary to take this middle position, are very difficult to be found, and too often the duties are undertaken by incompetent and inexperienced men, who by their blunders create a prejudice against a division of labor that benefits both the user and the manufacturer of steam machinery.

The wide, and we may add, the opening field of steam engineering is full of promise, indeed there is no branch of engineering to be compared with it as regards a certainty of radical and extensive improvement.

In marine engineering, alone, a lifetime is required to make but limited progress, and the influence of that progress will be felt throughout the whole world.

Finally, we must express the hope that these papers will not be entirely fruitless, but that some of our readers will, by their perusal, be induced to assist in the great and important work of STEAM REFORMATION.

MECHANICS, PHYSICS, AND CHEMISTRY.

*What should Mechanical Workmen be Taught?**

On Saturday afternoon, the 4th of June, a lecture on this subject was delivered, at the South Kensington Museum, by Mr. J. Scott Russell, F.R.S. The following abstract of it is principally taken from the report in the *Builder:*

The lecturer commenced by observing that he had the honor of appearing before them in a somewhat unusual capacity, in consequence of a conversation which had taken place not long ago between one of that great establishment and himself on the subject of the education of the class of workmen to whom he (Mr. Russell) belonged. Mr. Cole had shown him some papers which he had prepared for the purpose of examining workmen as to the progress which they had made in the kind of education generally provided for them; and expressed to him what he (Mr. Russell) now expressed, that the education provided in this country for workmen was not that which was very directly calculated to render them good workmen. He did not mean to infer that education did not make us all the better and wiser,—at all events it put into our hands the means of acquiring knowledge, and therefore reading, writing, drawing, and accounting, were good for the skilled workmen, and for every body else. It did not, however, consort with his experience that the best reader and the best writer were always the most skilled workmen; on the contrary, the best man he ever knew could neither read, write, nor account, and yet he was a very admirable workman. As a large employer of skilled labor, he now asked whether there was any description of education which, in their

* From the Journal of the Society of Arts, No. 344.

opinion, would tend greatly to the increase of the skill, dexterity, ability, and success, of the practical working mechanic. He maintained that there was, but that the mechanic did not get it. It was extremely difficult to give, but if the rising teachers of the next generation—if the institution in which they were then met—if the Government—really and earnestly cared about the mechanic, and wished to make him a good and skilled workman, and wished to keep the next generation of workmen where English workmen had ever been—namely, at the head of the workmen of Europe—he would show what it was their duty to do, and what ought to be done. It was, no doubt, difficult to accomplish; but, if they all pulled together, it could be done. It would want a good deal of money, large and wise views, and great energy and self-denial. Having said thus much of the difficulties of the undertaking, he would recommend them not to be disheartened, as, if a little seed were sown, a little agitation commenced, and a little ventilation given to the matter, the Government might be induced to do all that ought to be done. The matter, moreover, was a serious one, because the Governments of other countries were doing a great deal for the education of their practical mechanics, which we, as a nation, were not doing. He himself was obliged to get his very best draftsmen and mechanics from foreign countries. He had men in his employment from Prussia, Germany, and Holland; and he was bound to say, that, as far as preliminary education was concerned, although the workmen of foreign countries had not the skill obtained by the British workmen from practical experience, their scientific knowledge was greater, and that knowledge was telling so rapidly on the present generation of workmen, that we were now equalled (he would not say excelled) by the workmen of many countries upon whom we were inclined to look down a few years ago. He hoped they would clearly understand that he did not say anything against the education now given. On the contrary, he would say, "Continue to teach drawing, reading, writing, and accounting, in the best manner you can; but if you have a class of young workmen coming forward to learn, think how you can turn the little time they can afford to give to the best advantage, so that you may raise them higher in the social scale and make them better workmen." In order to do this, it would be necessary to give them a higher class of education than they were ever taught before. They had already been taught arithmetic, and they could answer such questions as, "How many yards of ribbon at 3½d. can be bought for 30s.?" Now this was all very right and proper for shopmen and shopwomen, but would not do for mechanics. They were also taught geometry. They were taught the 16th, 17th, 18th, and 19th propositions of Euclid, but that description of knowledge was not of the slightest use to his workmen, or to any body else. They were also taught mechanics and the law of the lever. That was right; but then mechanics and the law of the lever were not ordinarily taught in books in such a way as to be of practical use to the British workman. We did not go far enough; but the pupil teachers whom he addressed were not to blame. The persons to blame were their teachers.

Two years was, perhaps, all the time that could be devoted to education, and six months were often devoted to as many books of Euclid, which were wasted for all practical purposes, unless, indeed, the student intended to become a professor. He would advise them to skip over the beginning, and devote the least possible time to Euclid—in fact, he would advise them to do a very heterodox thing—to cut off all the propositions but the useful ones. They might naturally exclaim: "Then how little will be left." Very little, he admitted—but plane trigonometry would be left. Suppose, for instance, a man had but six months in which to learn. Six weeks might, in that case, be given to Euclid, and then trigonometry might be commenced, solid geometry might next follow, and that constituted the whole education of the workman. But that was precisely what he did not get in the present day. He would also teach, in the six months, conic sections, and afterwards the nature of curves, within the first, second, third, and fourth degrees. He was aware he might be met by the exclamation—"Oh! but we shall be teaching them more than we ourselves understand:" but to this he would answer—"That is the fault of your education." Sir Isaac Newton discovered no less than 130 curves, and nine-tenths of them would be of great use to the mechanic, if he had them in two places—in his head and at his fingers ends. Having now got to teaching something which they did not know, and had not learned, the next thing they wanted was the assistance of the Government. Decent elementary text books were wanted for the higher departments in mechanics, but there were many able men versed in the sciences; and what he wanted the Department of Science and Art and the Government to do, was, to ask the four cleverest men in England to write, in the fewest possible English words, all that they knew, (not all that they had read,) or in fact so much of their brains as they carried about with them. If Government would but pay handsomely for these books, a set of treatises might be collected, such as the world never saw before, and such as would be sufficient to teach any mechanic his business. They might, it was true, say, "But we do not know where to get these clever men." But he knew where they were to be got. There were three of the four present at that moment; and if the Government would but give them a thousand pounds a-piece for writing the books, he was sure they would write them. What he said about geometry was true as to mathematics. Thirteen yards and a half at 3½d. was not what was wanted. Of far more importance to the working man was the comprehension of the laws and relations of numbers, so as to enable the working man to think in figures about the immediate business before him. Having explained the manner in which mechanics might make reduced or enlarged models, and the relations and practical properties of numbers, the lecturer illustrated the value of a knowledge on these points by an anecdote. He remembered an instance in which a respectable working man sent in a tender for £12,500 for a very large piece of work. The tender appeared to be low, and he obtained the order, and had got on some way with the work when he found he had made a trifling omission—he had forgot

to multiply by *two*. His figures were all right, but in one place he forgot his multiplication, and his whole calculations were wrong. He was of the opinion that geometry ought to be taught by a large and comprehensive system. Professor Airy had written the best and the clearest treatise the world ever saw upon weight or gravitation. It was published in the *Penny Cyclopædia*, and he recommended every working man to read it; for although the subject might appear to be a dry one, he would assure them it was most fascinating. Eilaw's Mathematical Treatise was also a succinct and admirable work, which would be found of the utmost practical utility to the working mechanic. The first and most important doctrine to remember in mathematics, was, that shape is not size and size is not shape. This might appear to be an axiom, and he thought it was as good as any in Euclid. The doctrine of similar triangles was a fundamental principle entitled to the dignity of an axiom: it was that, without regard to shape and size, any number of triangles might be made all of the same shape and not of the same size. Mr. Russell having illustrated this principle by drawings on the board, continued to say that, with respect to solid geometry, the two great duties in a workman's life were conversion of materials and adaptation to strength. A mason who used up a wrong stone, or a carpenter who selected a wrong plank, or piece of timber, showed that he was ignorant of one of the most useful portions of his art or calling. Now nothing would teach conversion of materials like solid geometry; it was, in fact, the daily business of the workman. It had been said that every block of marble cut from the quarry contained a beautiful statue, but the art was how to get it out of it. This was very true; for what workmen wanted to know was every shape, and how to get out another shape. The workman who took from a heap a block of stone or piece of timber that cost his master 50s., when a piece could be got answering quite as well which cost 25s., inflicted a loss upon his employer perhaps equal to a week's wages. Hence the necessity of acquiring a knowledge of solid geometry. But if there were beauty in the quantity of numbers, and in regular geometrical figures, there was infinitely more beauty in curves. It was the duty of many mechanics, especially of those engaged in ship building, to make curved lines. To him it had always been an interesting subject to learn how curves grew. He was aware that he might be told that the higher curves were never taught, but his answer was, that they might easily be taught, and that they were very easy of comprehension. In order to effect this, somebody who understood the subject, would have to be prevailed upon, not to write a book, but to put down in the shortest and plainest language what he knew of curves. This would be a treatise which the workman could understand, and would be well worth the thousand pounds which he hoped the Government would be prevailed upon to give to one of the four clever men to write. The lecturer then explained, with the aid of the board, the various mathematical figures known as conic sections, parabola, ellipse, hyperbola, and the movement of the comets. These, he contended, might be learned so as to make the workman master of the

principle within six months. The subject of the education of the workman was one which he had very much at heart. He did not know how it was to be given, but as the pupil teachers were present as an Institution which took charge of the mechanic, and a Government which was anxious for the spread of education, he would urgently beg of them to take counsel with half-a-dozen of the best mathematicians of the day, and arrange with them to write short treatises, which could be circulated at a cheap rate, and which could be taught in our elementary schools. He also thought that there ought to be a large quantity of apparatus—a sort of inventory of education—of every conceivable shape and object. In addition to these models, he would have the school-room hung round, not with pictures of animals, but with solid bodies, which could be explained and drawn. He would, in fact, impart any kind of practical rather than book knowledge. If drawings merely were used instead of models, he did not think the student could imbibe so correct a notion of the object to be produced or delineated. There was a mode of studying forms called *la théorie de développement*, but the plain English meant nothing more than making flat surfaces into round and angular forms (as models now made from sheets of paper, which was a most valuable mode of studying forms). If this description of education could be given, he would take the pupils educated in that department and give them three guineas a week. He might afterwards raise them to foremen with salaries of £500 a year, and that would be far better than remaining all their lives at the bench, earning 30s. a week. Machinery could now be obtained to do all the unintellectual drudgery of mechanism. He was not opposed to machinery and had no apprehension that it would supersede skilled intellectual handicraft. He would employ machinery to do all the drudgery that degraded the workman into a beast of burden. He would give him higher views of mathematics; he would show him that he was an intellectual, thinking being, with a soul for high and immortal things.

Mr. Russell concluded by expressing a hope that Government would seriously undertake the education of the working man, so as to enable us to maintain our superiority among the civilized nations of the world.

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*On the Tensile and Compressive Strength of various kinds of Glass.**

At a recent meeting of the Royal Society a communication was read "On the Resistance of Glass Globes and Cylinders to collapse from external pressure, and on the Tensile and Compressive Strength of various kinds of Glass," by William Fairbairn and T. Tate.

The researches contained in this paper are in continuance of those upon the Resistance of Wrought Iron Tubes to collapse, which have been published in the "Philosophical Transactions" for 1858. The results arrived at in these experiments were so important as to suggest further inquiry under the same conditions of rupture with other materials; and glass was selected, not only as differing widely in its physical properties from wrought iron, and hence, well fitted to extend our

* From the Lond. Builder, No. 859.

knowledge of the laws of collapse, but because our acquaintance with its strength in the various forms in which it is employed in the arts and in scientific research is very limited. To arrive at satisfactory conclusions, the experiments on this material were extended so as to embrace the direct tenacity, the resistance to compression, and the resistance to bursting, as well as the resistance to collapse.

The glass experimented upon was of three kinds:—

	Specific gravity.
Best Flint Glass,	3·0782
Common Green Glass,	2·5284
Extra White Crown Glass,	2·4504

Tenacity of Glass.—For reasons detailed by the authors, the experiments upon the direct tenacity of glass made by tearing specimens asunder are less satisfactory than those in the rest of the paper; and it is argued that more reliance is to be placed upon the tenacity deduced from the experiments on the resistance of globes to bursting in which water-pressure was employed, than upon the tenacity obtained directly by tearing specimens asunder. The results obtained by the latter method give the following mean results:—

	Tenacity per square inch in pounds.
Flint glass,	2413
Green Glass,	2896
Crown Glass,	2346

Resistance of Glass to Crushing.—The experiments in this section were made upon small cylinders and cubes of glass crushed between parallel steel surfaces by means of a lever. The cylinders were cut of the required length from rods drawn to the required diameter, when molten, and then annealed, in this way retaining the exterior and first cooled skin of glass. The cubes were cut from much larger portions, and were in consequence probably in a less perfect condition as regards annealing. Hence, as might have been anticipated, the results upon the two classes of specimens, although consistent in each case, differ widely from one another.

The mean compressive resistance of the cylinders, varying in height from 1 to 2 inches, and about ·75 inch in diameter, is given in the following table:—

Description of Glass.	Height of Cylinder in Inches.	Mean Crushing Weight per square inch.		Mean Crushing Weight per square inch.	
		In Pounds.	In Tons.	In Pounds.	In Tons.
Flint Glass,	1·0	29,168	13·021	37,582	12·313
	1·5	20,775	9·274		
	2·0	32,803	14·644		
Green Glass,	1·0	22,583	10·081	31,876	14·227
	1·5	35,029	15·628		
	2·0	38,105	16·971		
Crown Glass,	1·0	23,181	10·348	31,003	13,840
	1·5	38,825	17·332		

The specimens were crushed almost to powder by the violence of the

concussion; it appeared, however, that the fracture occurred in vertical planes, splitting up the specimen in all directions. Cracks were noticed to form some time before the specimen finally gave way; then these rapidly increased in number, splitting the glass into innumerable prisms, which finally bent or broke, and the specimen was destroyed.

The following table gives the results of the experiments upon the cut cubes of glass:—

	Mean Resistance to Crushing.	
	In Pounds.	In Tons.
Flint Glass, . .	13,130	6·861
Green Glass, . .	20,206	9·010
Crown Glass, . .	21.867	9·762

Hence, comparing the results on cylinders with those on cubes, we find a mean superiority in the former case in the ratio of 1·6 : 1, due to the more perfect annealing of the glass.

Aerometry. Translated from the Hydraulics of D'Aubuisson de Voisins. By J. Bennett.

(Continued from page 241.)

THIRD SECTION.

We come now to the consideration of the force and the use of air as a motor; of its force, insomuch as it communicates motion by its impulse, or destroys it by its resistance; of its use, in that it gives motion to windmills (vessels coming under the special domain of the nautical art).

Chapter I.—*The Shock and Resistance of Air.*

All authors have regarded as identical the effects of the shock of air, and those of its resistance. If they differ at all, it can only be by a very small quantity, and in their constant co-efficient; for otherwise, they follow the same laws, and we proceed to discuss them under the common name of *resistance*.

545. *Mode of establishing the Resistances.*—The experiments and observations of Borda and of Hutton, have led to satisfactory results upon this matter; I give the substance of them, and refer for the developments and details to the works of these two authors.*

I first give an idea of the contrivance used by them.

Imagine a movable cylinder upon two small pivots traversed perpendicularly to its axis by a rod, whose two halves make equal arms. At their extremity is fixed the body whose resistance is to be proved; and around the cylinder is wound a cord having different weights suspended at its end.

In operating, the weight is allowed to descend, and impresses upon the machine a motion of rotation which soon becomes uniform. This

* *Experiences sur la resistance des fluides*, par Borda. *Memoires de l'Academie des Sciences*, 1763.
Determination of the resistance of air: 36th of the *Mathematical tracts, and philosophical subjects, &c.*, by Hutton, 1812.

weight measures the resistance experienced by the body and the two arms: the latter found by a previous trial being deducted from the whole, gives that of the body. The velocity is known from the number of revolutions made by the machine in a given time.

546. *Laws of Resistance.*—The velocities of bodies moving in air are distinguished into small and great. The first do not exceed 33 ft.; the second, such as cannon balls and other projectiles, have been observed by Hutton from 328 ft. to 2000 ft.

At common velocities, the resistance is sensibly proportional to the square of the velocity. Thus, Borda, having fixed to his small mill square plates of ·1259 sq. ft., and having moved them with velocities from 6·7 ft. up to 29 ft., found that the resistances and the squares of velocities followed the same ratio, as may be seen below. Other experiments upon plates of ·279 sq. ft. and 6·34 sq. ft., have given the same equality.

Ratios	
of Resistances.	of Squares of Velocities.
1·00	1·000
0·50	0·499
0·25	0·247
0·125	0·124
0·062	0·062

At great velocities, the expression of the ratio between the resistance and the velocity is more complicated. Observation caused Hutton to express it by three terms: in one, the velocity is of the second power, in the second it is of the first power, and the third is constant. Designating by v the velocity of a ball, by d its diameter, the resistance is expressed by the following formula:—

$$d^2\,(\cdot 000068\,v^2 - \cdot 0161\,v + \cdot 674).$$

We observe that, the velocity of atmospheric air in a vacuum being 1296 ft. $= \sqrt{2\,g \times 26099}$, whenever the ball has a velocity over 1312 ft., there will be a perfect void behind it; and so the additional resistances will be constant and equal to the atmospheric pressure.

547. The resistance of air, as well as that of water (257), increases in a greater ratio than the surface of bodies impinging upon it.

Thus, the surfaces of the three plates of Borda, being as the numbers 1, 2·25, 5·06; the resistances were as 1, 2·44, 5·97; and thus have increased very nearly as the 1·1 power of their surface.

Hutton had similar results even upon similar bodies: thus, with two hemispheres presenting in motion their great circles, having areas as 1 to 1·8, he found the resistances as 1 to 2·06. In other experiments of the same author, the difference was a little less, but there always was a difference.

The effect of impulse of the air upon a surface would very probably be increased by surrounding it with a border (239). A similar effect is produced in giving a concave form to the surface shocked; sails, slightly bellying, impress a greater velocity upon vessels, though the

sagitta of the curvature should not be more than a fourth or third of the width of the sails.

548. All else being equal, the resistance of fluids is proportional to their density.

That of water being nearly constant, there was no call for its introduction in the formulæ of resistance of this fluid; its value was comprised in that of the constant co-efficient. But this is not the case with air, whose density varies from place to place with the season, and at different intervals, according to the state of the barometer and thermometer. It is proportional to the specific weight, which is

$$\cdot 03253 \frac{b}{1 + \cdot 0022\,(t - 32^\circ)} \quad (498).$$

549. *Resistance for Plates.*—Let ρ be this weight, s the plane surface shocked, and n a numerical co-efficient; we shall have for the resistance, in velocities below 33 ft., $n\,\rho,\ s^{1\cdot1}\,v^2$.

To determine n, I return to the experiments of Borda. He found that a plate with ·6388 sq. ft. of surface, moving with a velocity of 11·36 ft., met a resistance of ·1672 lbs.; the barometer was then at 2·4846 ft. and the thermometer at 41°, which gives $\rho = \cdot 07924$: we have, consequently, $\cdot 1672 = n \times \cdot 07924\,(\cdot 63886)^{1\cdot1}\,(11\cdot361)^2$, whence we deduce $n = \cdot 02677$; with the plate of ·2798 sq. ft., he had ·02636; with that of ·1259 sq. ft., ·02653.

A plate of ·2222 sq. ft. used by Hutton, gave ·02581. Thus, we may establish for the expression of the resistance perpendicular to a thin plate, $0\cdot026\,\rho_1\,s^{1\cdot1}\,v^2$.

550. *Oblique Shock.*—When a body is presented obliquely to the shock of air, it meets with less resistance. To determine the relation between the resistance and the obliquity, Hutton took a rectangular plate, ·665 ft. at the base, and ·334 ft. in height; it was fitted to his small mill so as to have different angles from 0° to 90° with the direction of the motion. Calling i the angle of inclination, he found that this ratio was given with sufficient correctness by $(\sin.\ i)^{1\cdot84\cos.\,i}$. So that the general expression of resistance for a thin plane body, would be

$$0\cdot026\,\rho_1\,s^{1\cdot1}\,v^2\,(\sin.\ i)^{1\cdot84\cos.\,i}.$$

Here v represents either the velocity of the body when it moves in still air, or the velocity of the air as it impinges upon the body at rest, or the relative velocity $(v \mp u)$, when the fluid and body are both in motion.

551. *Resistance for differently formed Solids.*—Though the above expression refers particularly to simple plates or to very thin bodies, it may yet serve for all solids presenting a plane surface to the action of the air; observing, however, that their resistance is less by some hundredths.

But, it does not apply to bodies presenting an angle or convex surface; their resistance is much less. Borda and Hutton devoted themselves to its determination for triangular prisms, having two equal lateral faces, for cones, for demi-cylinders, and hemispheres. Each of these surfaces was first moved, presenting its plane surface to

the shock, and its resistance was adopted as the unit: then, the edge of the plane angle contained between the two equal faces for prisms, was placed in front, or the summit for the cones, or the convex surface for the demi-cylinder and the hemisphere. The resistance obtained, compared with that of the plane surface of the same body, is noted in the following table.

Alongside of the results of experiment, I indicate those of the ancient theory, or that which regarded the resistance as proportional to the square of the sine of the angle of incidence, and where, for a curved surface, the integral of the resistance of its differential element (267) was taken.

Each experiment presents by the initial letter of the name of Borda or Hutton, the indication of its author.

KIND OF BODIES.	RESULTS	
	of Experiment on n'.	of Ancient Theory.
B. Prism, at a plane angle of 90°, . . .	0·728	0·50
B. Prism, 60°, . . .	0·520	0·25
B. Cone, angle at summit of 90°, . . .	0·691	0·50
B. Cone, 60°, . . .	0·543	0·25
H. Cone, 51° 22′, . . .	0·433	0·19
B. Demi-cylinder, ...	0·570	0·67
B. Hemisphere and entire sphere, . . .	0·410	0·50
H. Hemisphere, ...	0·413	0·50

The resistance of these will then be very nearly expressed by

$$0{\cdot}026\, n'\, \rho_1\, s_1^{1{\cdot}1}\, v^2,$$

n' being the co-efficient indicated in the table, and s_1 the projection of the surface shocked, upon a plane perpendicular to the direction of motion.

552. *Examples.*—To determine the effort to be exerted by a current of air upon a plate 10·76 sq. ft. of surface, against which it impinges perpendicularly, with a velocity of 26·24 ft., the condition of the atmosphere being that of the mean for France. We have, then, the height of the barometer, $b = 2{\cdot}477$ ft., and that of the thermometer, $t = 53{\cdot}6°$; consequently, $\rho_1 = {\cdot}07687$. Moreover, $s = 10{\cdot}76$ and $s^{1{\cdot}1} = 13{\cdot}65$, $v = 26\,247$ ft. and $v^2 = 688{\cdot}9$. These values substituted in the expression $\cdot 026\, \rho_1\, s^{1{\cdot}1}\, v^2$, give 18·79 lbs. for the required effort.

I give in the following table the effort exerted by different winds upon the same plate.

KIND OF WINDS.	VELOCITY		EFFORT upon 10·76 sq. ft.
	per second.	per hour.	
	feet.	miles.	lbs.
Gentle wind, ...	6·56	4·3	1·19
Fresh breeze, ...	19·68	13·6	10·70
Wind best for mills, ...	22 96	15·5	14 60
Stiff breeze (good for navigation),	29 52	19 8	24·10
High wind, ...	39·36	26·7	42 9
Very high wind, ...	49·20	33·5	67
Gale, ...	65 60	44·7	119

Storms occur where the velocity is as high as 131 ft. to 147 ft., with force sufficient to upset houses.

II. A very high wind with 33 ft. velocity, impinges against a sail or rectangular plane

surface, 33 ft. base, and 6·5 ft. high, and inclined as a mean at 70° with the direction of the wind. What effort does it resist?

We have $s = 214{\cdot}5$ sq. ft. and $s^{1{\cdot}1} = 366{\cdot}9$ sq. ft., $v = 33$ ft. and $v^2 = 1089$; as above we make $\rho_1 = {\cdot}07687$: thus the direct shock would be ${\cdot}026 \times {\cdot}07687 \times 366{\cdot}9 \times 1089 = 798{\cdot}6$ lbs. We must multiply by $(\sin.\, i)^{1{\cdot}84 \cos.\, i}$, or since $i = 70°$, by $0{\cdot}9397^{1{\cdot}84 \times 0{\cdot}342} = 0{\cdot}9397^{0{\cdot}6292} = 0{\cdot}9616$; and we have 767·9.

III. A ball 0·1968 ft. diameter, is impressed with a velocity of 21·32 ft. against a current of air having a velocity of 8·2 ft.; the barometer is at 2·46 ft. and the thermometer at 68°; what will be the resistance experienced by the ball?

The relative velocity of the shock is $8{\cdot}2 + 21{\cdot}32 = 29{\cdot}52$ ft.; the surface s, which is the area of the great circle, is $\pi^1 \times ({\cdot}1968)^2 = {\cdot}030418$ sq. ft. Moreover,

$$\rho_1 = {\cdot}032533\ \frac{2{\cdot}46}{1 + {\cdot}00222(t - 32°)} = 0{\cdot}0741 \text{ lbs.};$$ and the table of No. (551) gives $n' = 0{\cdot}41$. Thus the required resistance will be ${\cdot}026 \times 0{\cdot}41 \times {\cdot}0741 \times {\cdot}030418 \times 29\,52^2 = 0{\cdot}02094$ lbs., which will be the retarding force.

Chapter II.—*Windmills.*

553. *Parts and Principal Dimensions.*—The part of these mills which receives the action of the wind, which is all that we shall consider here, consists, 1st, of a strong shaft of wood, from 1·64 to 1·97 ft. square, established at the upper part of the mill, which is turned and set with it, so as to be always in the face of the wind; it is generally inclined from 10° to 15° with the horizon. 2d, Of two other pieces, about 79 ft. long and 0·98 ft. square, fixed across the head of the shaft; these form the four arms. 3d, At 6·5 ft. from the centre of rotation, each is traversed perpendicularly to its length by the first cross-bar 6·5 ft. long, making an angle of 30° with the plane of the four arms, or the plane of motion; then, at intervals of 1·3 ft., are placed similar cross-bars, but inclined less and less, so that that which is at the end may have an angle from 12° to 6° according as the shaft is more or less inclined to the horizon. The ends of the cross-bars on both sides are stayed by two other struts. The whole combined, constitutes a wing of the mill. 4th, Upon this is stretched a cloth or sail to receive the action of the wind. Such are quite nearly the dimensions and disposition of the well-constructed Holland mills. Their sails, on account of the arrangement of the cross-bars and sometimes of a slight curvature of the arms, present a concavity to the wind, and we have seen that such a form increases the effect of the machine.

554. *Best Disposition of the Wings.*—Mathematicians have studied the best form and inclination to be given to the wings, or, as it is technically termed, the best method of weathering them.

Parent, who first investigated this matter, as well as nearly all the machines moved by fluids, in supposing the wings to be entirely plane, concluded that it was necessary to incline them 54° 44′ to the direction of the wind, or what amounts to the same, 35° 16′ upon the plane of motion. He admits that the effort of the wind is proportional to the square of the angle of incidence, to $\sin.^2 i$, calling i this angle; its component in the direction of motion, and so its motive effort being proportional to $\sin.^2 i \cos.\, i$, it must be the greatest possible when this expression is a *maximum;* now differentiating and making equal to zero, we have tang. $i = \sqrt{2}$, and, consequently, $i = 54° 44'$.

In the hypothesis admitted by Parent such is the angle of the greatest effort when the sail is at rest; but not so when it is in motion. Bernouilli has shown that the angle increases, or that its complement, the angle with the plane of motion, diminishes with the increased velocity of the sails. Maclaurin also remarks that the velocity of the different transverse elements of the same sail increasing with the distance from the axis of

rotation, their inclination should be diminished, and he gives the value of the angle of each for the greatest effect.

Euler, in his theory of windmills, first supposing the surface of the sails to be plane, finds that the effect is proportional to the surface, to the cube of velocity of the wind, and to the cube of the sine of the angle of incidence. Then, varying the inclination of the transverse elements, he has the same value as Maclaurin for the greatest effect; but he gives no finite expression of this effect.

M. Coriolis has the formula $\cot. j = \frac{3\,w\,x}{2\,v} + \sqrt{2+\left(\frac{3\,w\,x}{2\,v}\right)^2}$, designating by v the velocity of the wind, by w the angular velocity of the sails, by x the distance of one of the transverse elements from the axis of rotation, and by j its inclination to the plane of motion. He used this expression in the research for the maximum effect of the sail. He gives its differential equation, and shows the manner of applying it. He has made some important remarks upon this subject, for which reference may be made to his work upon the "*Calcul de l'Effet des Machines*" (p. 210–230).

555. Experiment has aided in the elucidation and decision of this question. It has been handled intelligently and successfully by Smeaton.*

This engineer made use of a small mill with four sails, each of which was 1·5 ft. long and 0·46 ft. wide; it was fastened to the end of a horizontal bar, 5·35 ft. long, the other end of which was planted upon a vertical cylinder movable round its axis. When a motion of rotation was given it, the mill partaking of this motion shocked the air with a velocity which represents that of the wind impinging upon the sails of a common mill, and which has consequently been taken for it. By reason of the shock, the mill turns round its own axis, and, by means of a cord wound round its axle, it raises the weights which serve as a measure of the effect produced.

Smeaton first investigated the best method of weathering the sails; and, with a velocity of 6 ft., he made various experiments, among which were the following:

He first took plane sails, and according to the directions of Parent, he inclined them 35°: a weight of 7·56 lbs. (comprising the resistance of frictions) was raised 2·28 ft. in one minute: thus, the dynamic effect in this time, was	17·22 lbs. ft.
Of all the inclinations of the plane wings, that of 15° gave the greatest effect, and was	25·18
On inclining the different cross-bars of the same wing, the quantity indicated for each of them by the rule of Maclaurin, that of the end bars being from 32° to 15°, the effect was	28·58
Finally, arranging these bars according to the Dutch method, so that the sail presents a slight concavity to the wind, the greatest effect was when the extreme angles were from 22½° to 7½°; it was then raised to	34·65
By increasing the surface of the sails one-quarter by means of a triangular strip, they had	44·50

From the various observations upon the mill, as well as from those of great mills, and attributing to the wind its common velocity, when it yields good effects, Smeaton recommends the division of the length of each arm into six equal parts. At the extremity of the first, starting from the centre of rotation, is placed the first cross-piece, inclined 18° to the plane of motion; the inclination of the second is 19°; that of the third (middle of the wing) was also 18°; that of the fourth 16°; that of the fifth 12½°; and at the end of the wing it was only 7°.

Smeaton also thought there was an advantage in making the sails larger at their end by giving them the form of a trapezium with bases as 5 to 3, the greatest of which to be one-third the length of the arm.

556. *Laws of Motion.*—The same author concluded from many other experiments made with velocities of wind from 4·3 ft. up to 8·7 ft.:

* "On the Construction and Effects of Windmills."

1st. That when the sails are most advantageously weathered, and without load, the velocity at their end is four times greater than that of the wind.

2d. That when they are loaded so as to produce a maximum effect, the velocity of the end is not over 2·7 that of the wind: 2·5 times in the mills of Flanders, according to Coulomb.

3d. That, consequently, in the case of greatest effect, and in those in its vicinity, the velocity of the sails is in a constant ratio with that of the wind; it is proportional to it.

4th. That in similar cases, the loads are nearly proportional to the square of the velocity of the wind; thus, the velocities being increased in the ratio of 1 to 2, the loads have increased in that of 1 to 3 75.

5th. That the effects which are in the compound ratio of the loads and velocities, will be nearly as the cubes of the velocities. In these experiments, the effects have a mean increase as 1 to 7·02, the velocities being as 1 to 2. We have already seen that Euler has admitted this ratio of the effects to the cubes of the velocities, and yet, the experiments made in Holland and reported by this geometrician, indicate that they are too great.

Moreover, Smeaton, as well as Euler and other authors, regard the effect as proportional to the surface of the sails (though we have elsewhere shown them to be rather in the proportion of $s^{1\cdot1}$).

557. Admitting the ratios above indicated, as well as a good disposition of the sails, the expression of the dynamic effect of a windmill would be $n\,s\,v^3$; s being the surface of the four sails, v the velocity of the wind, and n a constant co-efficient on the supposition of a mean density of the air. This co-efficient will be given by experiment.

Smeaton reports one where he had $s=2\cdot8062$ sq. ft., $v=8\cdot7501$ ft.; the weight raised was 17·61 lbs., and the height of elevation in 1 sec. ·1019 ft.; and, consequently, the dynamic effect was 1·7894 lbs. ft.; he then had $1\cdot7894 = n\times 2\cdot8062\times(8\cdot7501)^3$: whence $n=0\cdot00095$. The experiment reported above, where the effect in one minute was 34·65 lbs. ft. with a velocity of wind equal to 6 ft., also gave $n=$ ·00095. Thus, the experiments of Smeaton indicate for the value of the maximum effect, $\cdot00095\,s\,v^3$.

558. But can a formula based on observations made upon a small model of a mill receiving the action of the wind differently from common mills, be applied with confidence to the determination of the effects of great mills, effects which are two, three, and four thousand times greater? Prudence demands at least a verification made upon one of the great mills. An experiment made by Coulomb, with all the discernment and exactness which characterize the numerous and useful works of this skilful philosopher, causes us to give an account of it.*

In the environs of the City of Lisle, there are a great number of these Dutch mills, whose principal dimensions we have recorded; and Coulomb, observing that the small variations in the disposition of their sails did not occasion variations of effect, concluded that their construction was very near the maximum of perfection. Many of them were used for the extraction of rape-seed, for which purpose their shafts have cams which raise

* *Observations sur l'Effet des Moulins a vent*, in the *Memoire de l'Academie des Sciences*, year 1781.

up the great pestles. In the experiment just mentioned, when the velocity of the wind was 21·3 ft., six pestles, weighing in all 6044 lbs., were each raised 26 times in one minute 1·59 ft.; consequently, the useful effect in one second, was . 4186 lbs. ft.

The friction, from a special observation to determine it, consumed a quantity of motive action equal to . . 354·5

The loss of *vis viva* occasioned by the shock of the cams against the ears of the pestles, was estimated at . . . 316·2

In all, for the dynamic effect, . . 4856·7

Moreover, $s = 873{\cdot}2$ sq. ft.; thus, $4856{\cdot}7 = n \times 873{\cdot}2\ (21{\cdot}32)^3$; whence we derive $n = 0{\cdot}00057$.

559. This value of n would give smaller effects than those indicated by the experiments of Smeaton, in the ratio of 3 to 5. Though I do not doubt the exactness of the observations of the English Engineer, still as those of Coulomb were made upon mills more similar in their disposition and magnitude to those for which the formulæ are applicable, I believe the preference should be given to their results, the rather that in estimating the effect of machines, an error below the reality does not occasion any serious result in practice. We shall then establish for the general expression of the dynamic effect of windmills, $0{\cdot}00057$ lbs. ft. $s\,v^3$.

Finally, we only admit this formula as furnishing a simple approximation; for it is doubtful after what has been said whether their effects are exactly proportional to the surface of the sails, and the cubes of the velocities.

This expression is of the same kind as that giving the effect of mills placed upon rivers, which we have seen to be $0{\cdot}400\ s\,v^3$ (333). In the last case, the wheels move in an indefinite fluid; but here, the fluid being about 800 times less dense, its action will be 800 times less, and the effect would not be over ${\cdot}0005\ s\,v^3$; an expression whose co-efficient is still smaller than that indicated by the observations of Coulomb.

560. *Economical Effect.*—We have admitted that to grind a hectolitre (2·75 bushels Imp.), there must be impressed upon the mill-stone a force of two horse-powers, or of 1085 lbs. ft. in 1 sec. Though the above force, $0{\cdot}00057$ lbs. ft. $s\,v^3$, was measured upon the shaft, and must have experienced a slight diminution in its passage to the stone, we may preserve it as it is; and it will indicate, for the quantity of corn which a windmill can grind in one hour, at most

$${\cdot}0000005\ s\,v^3 \text{ hect.}$$

Coulomb states that the mills of Flanders, with a wind of 19·2 ft. velocity, yield from 5·2 to 5·8 hectolitres per hour: such a product, which seems large to me, would advance the economical effect, as a mean, to $0{\cdot}00000085\ s\,v^3$.

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*Removing Scale from Boilers.**

A series of important experiments have, during the past eight months, been carried out at Portsmouth on board Her Majesty's paddle steamer *Wallace*, under the supervision of Mr. G. Murdock, inspector of machinery afloat at that port. The object sought to be attained, is the removal of the scale generated on the surface of steam boilers and their tubes, by other and more expeditious means than by

* From Mitchell's Steam-shipping Journal, Dec., 1859.

the present system of manual labor. The importance of the subject will be fully comprehended by all who may be in the slightest degree conversant with steam machinery. Under the present system, should a ship's boilers require cleaning out, or clearing from scale, while on board the ship, all the boiler doors have to be taken off and a number of men sent into the boilers to clear the scale by manual labor. By these means, with the greatest exertions and any amount of time, possibly 10 per cent. of the scale might be removed, and with this small improvement the engineer well knows the relief he finds in getting steam. By the system which has now been undergoing so long a series of tests on board the *Wallace*, only one door of the boiler has to be taken off to allow the introduction of the steam pipe. The boiler to be acted upon is then filled rapidly with superheated steam at a temperature of 400° of heat; this acting upon the saline deposits on the surface of the tubes, and other parts of the boiler, expands and disengages it from the several parts. After this, the boiler is again filled with water, and steam got up in the usual manner, and kept up for a few hours, and on afterwards blowing off the boilers, they are found to be as free from scale as when they were first put on board the ship. The experiments have been highly successful. The saving of fuel alone in our steam ships of war from adapting this plan to their boilers, will be very considerable, and the whole scale may be removed from a ship's boilers in 12 hours. A very remarkable specimen of scale may be seen in the chemical laboratory in Portsmouth Dockyard, which was removed from the boilers of Her Majesty's ship *Sidon* when under the command of Sir Charles Napier. The impression of the tubes on the scale is perfect.

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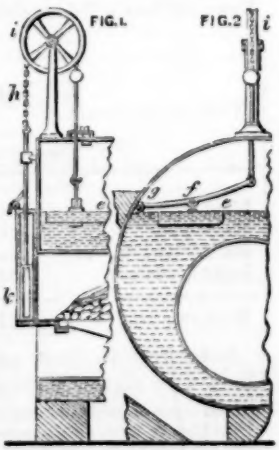
*Wright's Method of Preventing Boiler Explosions.**

Mr. E. T. Wright, Engineer, of Wolverhampton, has just patented the method of preventing boiler explosions by connecting a water buoy or float in the steam boiler with the furnace or door, with a door opening into the furnace, so that when the water in the boiler falls below a given level the door is opened, and cold air is admitted into the furnace, "whereby the boiler is cooled, and the draft through the fire to a great extent suspended; the overheating and consequent danger of explosion of the boiler is thereby prevented, and the attendant on proceeding to fire is warned of the state of the water in the boiler by the open door." The inventor sometimes connects the float in the boiler with the furnace door by means of a chain and pulley, as illustrated in the engravings, Figs. 1 and 2; *e* is the float hung to the lever *f* in the boiler. The said lever *f* turns upon a fulcrum at *g*; a chain *h* passing over the pulley *i* connects the float *e* with



* From the Lond. Practical Mechanics' Magazine, May, 1859.

the furnace door *k*. By the descent of the float *e* the furnace door *k* is raised. In boilers of the kind represented, the distance between the water level and the furnace flue is sometimes insufficient to allow of the descent of the float through the requisite distance when the said float is immediately over the said flue. On this account the float is placed on one side as shown.

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*On the Weight and Strength of American Ship-timber.** By DONALD MCKAY, Ship-builder, of Boston, U. S.

WEIGHT OF A CUBIC FOOT OF

	Virginia White Oak.		Virginia Yellow Pine.†	
	Round.	Square.	Round.	Square.
	lbs.	lbs.	lbs.	lbs.
After felling, . .	64·74	67·20	47·81	39·21
1 year after, .	53·60	53·51	39·83	34·16
4 years after, . .	45·97	49·89	34·28	33·49

Each of the above numbers are the mean of experiments on twelve different pieces of timber cut from different trees, and the experiments were made by Mr. Farris, Timber Inspector of Gosport Navy Yard.

WEIGHT OF A CUBIC FOOT OF LIVE OAK, ACCORDING TO GRIFFITH.

Green, . . 78·69 lbs. | Seasoned, . . 66·75 lbs.

This timber is exclusively used for the frames of the United States men-of-war ships, and is considered by all naval men to be almost imperishable.

TENSILE STRENGTH OF AMERICAN WHITE OAK AND ENGLISH OAK PER ONE SQUARE INCH.

(*From "Appleton's Dictionary of Mechanics."*)

English Oak, 8820 to 10,224 lbs. American White Oak, 11,501 lbs.

SPECIFIC GRAVITY AND TRANSVERSE STRENGTH (PER ONE SQUARE INCH) OF ENGLISH OAK AND AMERICAN WHITE AND LIVE OAK.

(*According to various observers.*)

Extracted from a Table published in Vol. V. of the Professional Papers of the Royal Engineers.

Name of Observer.	English Oak.		American White Oak.		American Live Oak.	
	Spec. gravity.	Strength.	Spec. gravity	Strength.	Spec. gravity	Strength.
		lbs.		lbs.		lbs.
Lieut. Nelson, .	834	1629	645	1699	1160	1862
Mr. Moore, . .	816	1919	836	1699		
Mr. Barlow, . .	934	1672	872	1766		
Lieut. Dennison,	733	1556	772	1809		
Mean results, . .	829	1694	781	1743	1160	1862

According to these experiments, the advantage of lightness, combined with strength, is entirely on the side of American White Oak.

* From the Lond. Mechanics' Magazine, Dec. 1859.

† The Virginia Pitch Pine is called in America "Yellow Pine." The Florida Yellow Pine is called the "Long-leaf Yellow Pine," and weighs about 41 lbs. per cubic foot.

For the Journal of the Franklin Institute.

Particulars of the Steamer Benjamin Déford.

Hull and machinery built by Harlan & Hollingsworth & Co., Wilmington, Del. Intended service, Bahama to Savannah.

HULL.—

Length on deck, from fore part of stem to after part of stern post, above the spar deck,	214 feet.	
Breadth of beam at midship section,	33 "	
Depth of hold,	15 "	6 inches.
" to spar deck,	23 "	4½ "
Frame—of wrought iron.		
Floors, ⅛; molded, 4 ins.—sided 1⅛ ins.; and 16 and 18 ins. apart at centres.		
Plates—7-16 to 13-16 in. thick.		
Draft of water at load line,	12 "	
" below pressure and revolutions,	10 "	
Area of immersed midship section at this draft, 280 sq. ft.		
Tonnage, custom house, 1090 14-95.		
Contents of bunkers in tons of coal, 130.		
Masts and rig—Brigantine.		

ENGINE.—Vertical beam.

Diameter of cylinder,		56 inches.
Length of stroke,	11 feet.	
Maximum pressure of steam, 25 lbs.		
Maximum revolutions per minute, 19.		
Cut-off—one-half.		
Weight of engines, 280,000 lbs.		

BOILER.—One—Return tubular.

Length of boiler,	16 feet.	
Breadth "	16 "	6 inches.
Height " exclusive of steam chimney,	12 "	9 "
Weight " with water, 140,000 lbs.		
Number of furnaces, 4.		
Breadth "	3 "	8 "
Length of grate bars,	7 "	6 "
Number of flues, below, 4 arches.		
" tubes above, 212.		
Internal diameter of tubes,		4 "
Length of tubes,	11 "	
Heating surface (fire and flue), 3222 sq. ft.		
Diameter of smoke pipe,	5 "	3 "
Height "	55 "	
Description of coal, Bituminous or Anthracite.		
Combustion, Natural draft.		

PADDLE WHEELS.—

Diameter,	30 feet.	
Length of blades,	7 "	6 inches.
Depth "		19 "
Number " 26.		

Remarks.—The *S. R. Spalding*, lately built for the Merchants and Miners' Transportation Co., and running from Baltimore to Boston, is a sister built vessel to this. C. H. H.

For the Journal of the Franklin Institute.

Particulars of the Steamer Austin.

Hull and machinery built by Harlan & Hollingsworth & Co., Wilmington, Del. Intended service, New Orleans to Brazos.

HULL.—

Length on deck, from fore part of stem to after part of stern post, above the spar deck,	203 feet	6 inches.	
Breadth of beam at midship section,	34 "		
Depth of hold,	10 "		
" to spar deck,	17 "	9 "	
Frames—of wrought iron.			
Floor, ⌋; molded, 3½ ins.—sided, ⅞-ins.; and 16 and 18 ins. apart from centres.			
Plates—½-in. to 5-16 in. thick.			
Draft of water at load line,	7 "	6 "	
" below pressure and revolutions,	6 "	6 "	
Area of immersed section at this draft,	190 sq. ft.		
Tonnage, custom house,	642 77-95.		
Contents of bunkers in tons of coal,	260.		
Masts and rig—Schooner.			

ENGINE.—Vertical beam.

Diameter of cylinder,		44 inches.
Length of stroke,	11 feet.	
Maximum pressure of steam,	25 lbs.	
Maximum revolutions per minute,	17.	
Cut-off—half-stroke.		
Weight of engines,	230,000 lbs.	

BOILER.—One—Return flue.

Length of boiler,	24 feet.	
Breadth "	15 "	6 inches.
Height " exclusive of steam chimney,	9 "	2 inches.
Weight " with water,	120,000 lbs.	
Number of furnaces,	3.	
Length of grate bars,	6 "	2 "
Number of flues,	above, 8—below, 8.	
Length of flues, above,	19 "	2 "
Length of flues, below,	15 "	6 "
Heating surface (fire and flue),	1880 sq. ft.	
Height of smoke pipe,	50 "	
Description of coal,	Bituminous or Anthracite.	
Combustion,	Natural draft.	

PADDLE WHEELS.

Diameter,	30 feet.	
Length of blades,	6 "	6 inches.
Depth "		22 "
Number "	26.	C. H. H.

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*Permanent Building.—Fall of Houses in Salford.**

During Sunday last two accidents to dwelling houses occurred in Salford, but fortunately they were not attended by personal injury. About three o'clock in the morning, the front wall of a two story house in Cross-street, Bury-street, fell with an alarming crash, and rendered the place a ruin. The second accident occurred in Queen-street, soon

* From the Lond. Builder, No. 884.

after two o'clock on Sunday afternoon. A laboring man, named Jones, was about to sit down to dinner with his family in the upper front room of a cottage house in that street, when there came a loud crack, followed by two others, and a noise "like thunder" as the neighbors declare. The wood-work of the roof had yielded, and the whole mass dropped inward, until it bore upon the top of a large four post bed in the middle of the room.

Translated for the Journal of the Franklin Institute.

On Giffard's Automatic Injector for Steam Boilers.

By M. Ch. Combes, Inspector-General; Director of the *Ecole des Mines*. *Annales des Mines, 5th Series, Vol.* XV, *p.* 169.

The attention which this ingenious instrument for the water-supply to steam boilers has attracted in France, but more especially the merits of the description and theory of M. Combes, has induced us to lay this memoir before our readers; hoping to attract the attention of our young mechanics and engineers to the beauty and advantages of the French method of precise analysis of every machine. ED. J. F. I.

The apparatus recently invented by M. Giffard for feeding steam boilers, has justly attracted the attention of engineers by its originality. Already quite a number of applications of it have been made, both to the boilers of fixed engines and locomotives. It seems to me that it will be useful in publishing the description of it, to add some reflections or general explanations. I shall perhaps be able to complete them hereafter by the results of experiments which will be its natural and almost necessary complement. In the meantime, they will suffice to explain the action of this ingenious apparatus, and may be useful in deterring some persons with imperfect ideas of mechanics and physics, from attempting irrational applications of the natural phenomena of which M. Giffard has taken advantage with as much skill as discernment.

The steam boiler injector of M. Giffard contains no solid movable parts; it is founded upon the principle of the lateral communication of motion in fluids. The figure (Plate IV) presents a section of the apparatus by a plane passing through its axis. L is a tube through which the steam comes from the boiler, the discharge of which may be checked or entirely stopped by means of the stop-cock R. The steam penetrates by a number of openings into the interior of a cylinder, *c*, which terminates in a cone opening by a small circular orifice. A solid cylindrical rod, *t*, occupying the axis of the cylinder, is terminated by a conical point which may be pushed gradually into the ajutage which surrounds it, so as to change by degrees the size of the annular space by which the steam escapes. The rod *t* is moved forwards or backwards by means of a screw, the nut of which is fastened into the end of the cylinder opposite to the conical ajutage, and of a small winch on the outside, *m*. The steam issuing from the cylinder *c*, jets into

the interior of a short cone, broader than the conical ajutage of the cylinder, the end of which it surrounds, leaving between them a free annular space. In front of this second cone is the hollow space E, to which is applied the tube T, the end of which is plunged under the surface of the cold water contained in a vessel which may be placed 1 or 2 metres below E. The screw V, with its winch *n*, permit a change of the depth to which the conical ajutage of the cylinder *c* is inserted into the broader cone *d*. The figure will show how by turning the screw which takes into a nut firmly attached to the external envelope of the cylinder *c*, a slow movement in the direction of its axis is given to this cylinder and all the parts connected with it. When the steam jets through the terminal orifice of the ajutage of the cylinder, it draws with it the air contained in the cone *d* and the space E, into which the water soon comes through the pipe T. This water mixes with the steam and condenses it, and a jet of water issues from the orifice of the cone *d* with a velocity which depends on that which the steam had at its issuing from the cylinder *c*, and on the quantity of water drawn in. Exactly in front of the orifice by which the water jets, at a distance of 1 centimetre at most, is the orifice of another very much elongated cone, I, the axis of which is in the prolongation of the common axis of *c* and *d*, but the orifice of which is bored out in the opposite direction. The liquid vein issuing from the cone *d* thus jets directly into the interior of the cone I. This communicates with the boiler by the pipe L; and in the passage is interposed a valve or clack S, opening towards the boiler. This clack is shut when the apparatus is not in action, by the excess of the pressure in the boiler over that of the atmosphere. When the apparatus is working, and well-adjusted, the jet enters entirely into the cone I, and all the water passes into the boiler, forcing a passage through the clack S. The space E which exists around the extremities of the two opposed cones, *d* and I, communicates freely with the atmospheric air by circular openings, o o, which permit the water to be seen as it passes from the cone *d* to I. The vein is always opaque and troubled, either because the steam is not all condensed, or because a little air is drawn in with the water. The pipe T is for the purpose of discharging the cold water which may be drawn in in excess before the apparatus is in adjustment, and that which is formed by the condensation of the steam when the apparatus is first put into action; it opens into the atmosphere, and discharges these waste-waters into the reservoir of cold water.

The feeding by means of the Giffard injector is intermittent. The apparatus is put in action by opening the stop-cock R which allows the steam to come from the boiler. The quantity of steam expended may be altered, by thrusting the rod *t* more or less into the conical ajutage, and the quantity of feed-water is governed by plunging the conical ajutage more or less deeply into the cone *d*. The adjustment is easily and quickly made.

A cubic metre of saturated steam at the temperature of 152°, and under a pressure of 5 atmospheres or 5·165 kil. per square centimetre,

weighs (its weight being calculated by the laws of Mariotte and Gay-Lussac) 2·5962 kil. If we admit that the steam of this density and pressure (maintained constant) flows from the vessel which contains it into the atmosphere by an orifice, keeping its density as a liquid would, its velocity of issue would be (omitting the resistances occasioned by the form of the orifice) $\sqrt{2g\frac{P-p}{q}}$, where g denotes the gravity, P and p the respective pressures of the steam and the atmosphere upon the unit of surface, and q the specific gravity of the steam. On the assumptions above $\frac{P-p}{q}=15{\cdot}916$. But $g=9{\cdot}8088$; the velocity of issue of the steam would, therefore, be in the case assumed, 558·79 metres per second; and the height due to this velocity 15,916 metres.

If we suppose that, owing to the form of the vessel orifice or steam-tube, or to any other circumstances, the steam dilates before it reaches the orifice, so as to pass it with a density corresponding to the atmospheric pressure, its temperature being kept constant during the dilatation taking place in the interior of the vessel, the velocity of issue will be, in this case, given by the expression

$$\sqrt{2g\frac{p}{q}\text{ hyp. log. }\frac{P}{p}},$$

where q expresses the specific gravity of the steam under atmospheric pressure at the temperature of 152°, P, p, and g having the same meaning as before. Now $q=0{\cdot}519$ k.; $\frac{P}{p}=5$; $\frac{p}{q}\frac{10330}{0{\cdot}519}$. Introducing these numerical data into the formula, we find for the velocity of the steam issuing under atmospheric pressure 792·82 m. per sec.; the height corresponding to this velocity is 32,044 metres.

This indicates that the vapor at its issue has a velocity in virtue of which its particles considered as isolated and without action on each other, would ascend to a height of 15,916 or 32,034 metres, in vacuo, according as the steam had kept all its density and pressure or had been dilated in the pipe from 5 to 1 atmosphere. In other words the living force which the steam has at its issue corresponds to a quantity of work equal to the weight of the steam falling through a height of 15,916 or 32,034 metres according to the hypothesis we take; and this work is the theoretical work due to the steam, according as it acts with full pressure and without condensation against the external atmosphere, or acts by expanding from 5 to 1 atmosphere; its initial temperature being maintained during the expansion.

This being established, the steam immediately after passing into the atmosphere meets with water which suddenly condenses it, and forms with it a jet which is completely liquid. The velocity of the water which condenses the steam may be neglected in comparison with that of the steam itself, and the internal reaction which cause the condensation cannot modify the quantity of motion. If then we designate

by m the mass of the steam which flows out in the unit of time, by M the mass of the water, which mixes with this condensed steam to form the liquid jet, by v the velocity of issue of the steam, by u the velocity of the jet after condensation, we have $u = v\,\frac{m}{m+\mathrm{M}}$. The mass of the water must be sufficient to accomplish the entire condensation of the steam. Let the temperature of the water be 15°, we may, as an approximation, admit that the steam in condensing abandons 550 units of heat. If it is desired that the liquid jet should be at the temperature of 60° the ratio of M to m will be established by the equation $15\,\mathrm{M} + 650\,m = (m + \mathrm{M})\,60$; whence $\mathrm{M} = 13{\cdot}11\,m$. The weight of the water, therefore, under the condition assumed above, must be about 13 times that of the steam.

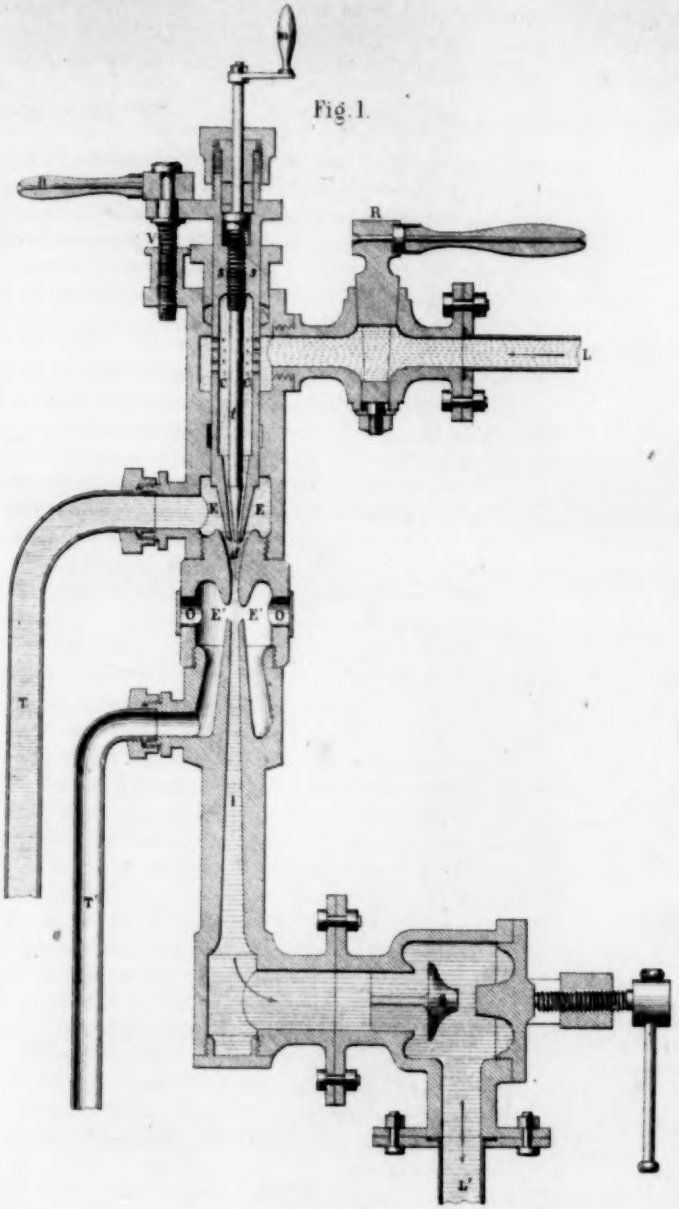
Admitting the weight of the water to be 15 times that of the steam, the temperature of the liquid jet will be found to be 57° or 58° (the water being taken at the temperature 15°). Let, then, $\mathrm{M} = 15\,m$; the velocity of the jet will be $\frac{1}{16}$ of that of the steam, and the height to which it will rise in virtue of this velocity will be $\frac{1}{16^2}\cdot\frac{v^2}{2g}$, while the isolated particles of the steam would have risen to the height $\frac{v^2}{2g}$.

But the weight of the liquid jet being 16 times that of the steam, its living force is $\frac{1}{16}$ of that of the steam before its condensation.

The velocity of the liquid jet being $\frac{1}{16}$ of that of the steam will be comprised between the limits 34·92 and 49·55 metres per second. If it be greater than that with which water at the temperature of the jet would spout from the boiler into the atmosphere, under an interior pressure of five atmospheres; it is evident that the liquid jet driven into an ajutage of proper form communicating with the interior of the boiler, will enter the boiler driving back the water which tends to escape. Now if neglecting the effect of the dilatation of the water between 3° and 58°, we assume 1 kil. as the weight of 1 litre of the water of the jet, we shall have for the velocity with which the water at this temperature will tend to pass from the boiler into the atmosphere 28·37 metres. A velocity so far below the lowest limit which we found for the jet, that we may regard as certain, the possibility of forcing into the boiler with the steam which has issued from it a weight 15 times greater than that of this steam. The water at its entrance will have a temperature of about 57°.

It will be seen that the jet could not enter the boiler if its velocity fell as low as 28·37 metres per second. Now this would happen with a weight of water equal to $\frac{558{\cdot}79}{28{\cdot}37} - 1 = 18{\cdot}7$ or $\frac{792{\cdot}82}{28{\cdot}37} - 1 = 27{\cdot}9$ times the weight of the steam, according as the steam at the moment of mixing with the water, is supposed to have a velocity of 558·79 or 792·82 metres per second. It is pretty certain that the velocity of the steam is much nearer the first limit than the second; and if this

Fig. 1.



Scale of 6" to 1 metre.

0.1 0.2 0.3 0.4 0.5 dec.

be really so, the quantity of water which it is possible to introduce into the boiler by means of the injecting apparatus, will be at the greatest 18 times the weight of the steam used in the apparatus.

The volume of feed-water which it is possible to drive into the boiler by means of M. Giffard's injector increases in proportion as the effective pressure (that is, the excess of the pressure of the steam over that of the atmosphere) increases. Thus, for instance, if the effective pressure is only half an atmosphere, the weight of the cubic metre of steam under that pressure and the corresponding temperature 111° will be 0·8349 kil. The formula gives in this case, for the velocity of the steam issuing into the atmosphere without previous expansion, 332 metres per second. The velocity with which the liquid water would spout under a pressure of half an atmosphere, would be only, in round numbers, 10 metres per second; whence it follows that the steam could draw with it 30 times its weight of water, the liquid jet still preserving sufficient velocity to penetrate into the boiler. The limit thus roughly determined is undoubtedly too high, because, on the one hand the velocity of the steam is diminished by the resistances of the pipes and ajutage, and on the other hand the density of the liquid jet is diminished by the rise of the temperature, perhaps by imperfectly condensed steam, and by the air drawn in. But it is nevertheless certain that the feed will be more certain and may be made more abundant in proportion as the effective pressure in the boiler is less.

As an apparatus for feeding steam boilers, the injector of M. Giffard is without doubt the best of all those hitherto employed, and the best that can be employed, as it is also the most ingenious and simple. If, in fact, in conformity with the old ideas, we suppose that the quantity of heat contained in bodies is preserved integrally; then, whatever changes of volume or state they undergo, independently of the quantity of work done, or of resistances which are the consequences of these changes, it is clear that the action of the Giffard apparatus will give occasion to no loss of heat except that which will take place by radiation, or by contact of the boiler and its appurtenances with the surrounding air. The feeding will then be gratuitous.

If, conformably to the more rational principles of the new dynamic theory of heat, we admit that the heat is transformed into work, and *vice-versa*, so that all the work or resistances, all the living forces, developed or destroyed in the changes of volume or state of bodies, are accompanied by a disappearance or production of an equivalent heat; the quantity of heat expended in the Giffard apparatus will be precisely (neglecting the losses by radiation and contact with surrounding mediums,) equivalent to the quantity of work corresponding to the elevation of the feed-water from the reservoir whence it is taken, and its forcing into the boiler against the pressure which exists there. We are therefore authorized to assert that the apparatus of M. Giffard as a feed-pump for boilers, is theoretically perfect. But machines constructed on the same principle as this apparatus, for the elevation of water, or more generally for the purpose of moving masses of liquids or gases, so that the heat contained in the jet formed by the mixture

of the steam and the liquids or gases drawn in by it, would be of no use in the final effect, would be very poor machines as regards the economy of work. Thus we have seen that if the steam draws in with it n times its weight of water or any other fluid, the living force of the jet is reduced to the fraction $\frac{1}{1+n}$ of the living force which the vapor had at first, so that the living force lost is the fraction $\frac{n}{n+1}$ of the primitive living force. This loss increases enormously with the ratio of the weight drawn in to the weight of the steam, and this ratio would generally be very great.

A jet of steam issuing with a velocity due to a pressure of 5 atmospheres, can draw with it 50 times its weight of water and lift it to a height which in round numbers would be nearly 6 metres. The loss of work in this case would be $\frac{50}{51}$ of the total work which the steam could have developed had it acted with full pressure without expansion or condensation, against the external atmosphere.

If a jet of steam with the velocity here supposed, draws in 10 times its weight of atmospheric air, acting thus as a blowing-machine, the living force of the jet of damp air would not exceed $\frac{1}{11}$ of the living force of the steam; that is, the work which would have been theoretically performed by the steam acting against the pressure of the atmosphere, without condensation.

The apparatus of this kind which are now and may hereafter be used, may, no doubt, be advantageously employed under peculiar circumstances, owing to their extreme simplicity; but they not the less remain very bad machines in reference to the economy of motive power.

M. Giffard perfectly well understood this. The merit of his ingenious invention therefore consists in its application to steam boilers, and the construction of an apparatus which works with perfect ease and regularity: which, for example, at the Imperial Tobacco Manufactory, where it suffices for the feed of boilers of 200 horse-power, injects per hour, as we have been told, as much as 4 cubic metres (*tons*) of water.

Some persons have claimed the priority of invention over M. Giffard. If they have not made use of the steam-jet from a boiler for the feed of that same boiler, or realized other applications in which the heat contained in the jet drawn in by the steam plays the principal part, they have, in our opinion, made but bad machines, founded on a fact long known and applied, viz: the drawing along of gases or liquids by lateral communication.

The Giffard Injector has been applied for a month past to a locomotive on the Paris-Strasbourg railroad. At first the feed-pumps were left in place, so that they might be used in cases of necessity; but there was no occasion to have recourse to them, and after it was ascertained that the working of the injector was easy and sure, the pumps were removed two weeks since.

The Injector is placed horizontally and fixed by two iron clamps

upon the left side of the boiler; the winches of the two screws, *m* and *n*, are turned towards the rear, so as to be near the driver; the space surrounding the conical ajutage of the cylinder which receives the steam, is put by a pipe into communication with the tender. The conical tube, I, which receives the liquid jet, enters a vertical cylindrical box containing the clack S, which is placed above the point of insertion of the pipe into the box. Above the clack is inserted the pipe which opens into the boiler near the lower and front part, at the same point where the feed-pipe from the pump was formerly inserted. The cylindrical box is closed above by a plate fixed by a stirrup and screw, so that the clack is easily accessible, even while the machine is in motion. The cylindrical box which unites the two parts of the apparatus, opens into the atmosphere, and along its axis the liquid vein can be seen passing from the injecting into the receiving cone; it is furnished at its lower part with a short tube, by which the water drawn in, when it has not been entirely received into the cone I, is discharged; it falls under the eye of the observer into a funnel whence it may be re-conducted into the tender. When the apparatus is not in action, the stop-cock of the steam-pipe is closed, and the rod, *t*, is pushed into the ajutage. When the engine-driver wishes to feed, he first opens the stop-cock, the steam enters the cylinder which it heats up by its own partial condensation, but it cannot escape owing to the position of the rod; this is withdrawn by turning the winch of its screw immediately after the opening of the stop-cock. The water from the tender is immediately drawn in; the whole of that which comes in does not at first penetrate into the receiving cone: a part flows off by the waste-pipe. In order that this discharge may cease, and that the whole of the water drawn in may penetrate into the receiving cone and thence into the boiler, the conical ajutage of the cylinder, *c*, must be properly inserted in the exterior cone. The depth of the insertion, which is regulated by the driver by means of the screw and winch *n*, must be greater and the annular space through which the water passes consequently narrower, as the pressure is less in the boiler. Thus, for example, if, at the moment the apparatus is set to work, the steam gauge of the boiler indicates 7 atmospheres, and the ajutage has been so adjusted that the whole liquid jet penetrates into the receiving cone, and no water escapes by the discharge-pipe, this latter pipe will show water so soon as the gauge indicates a perceptibly lower pressure, and the more the pressure falls the greater the quantity of water wasted. To stop this waste, it is necessary to push the ajutage farther into the external cone in proportion as the pressure falls; the effect of this adjustment is so sensible that the engine-driver informed me that he could tell the pressure in his boiler as well by the amount of adjustment necessary to stop the waste, as by reading the gauge. When it is desired to feed by the Injector, a locomotive at rest, before its steam is up, the interior pressure being, for instance, not more than $1\frac{1}{2}$ or 2 atmospheres, the ajutage must be pushed very far into the cone, and for this purpose it is necessary to make several revolutions of the screw V; the winch ought therefore to be so adjusted that this may be easy.

This is not the case in the locomotives on the Eastern Railroad; the winch not being able to make an entire revolution, the driver is obliged to remove and replace it on its square, when he wants to feed before his steam is up.

It is evident that by contracting the annular space between the ajutage and the cone through which the water drawn in passes, the volume of this water is diminished. The facts which I have just mentioned, are not at variance with that which I said as to the greater ease of feeding a boiler by the Injector in proportion as the internal pressure diminishes; the weight of the steam expended in the unit of time diminishes much more rapidly in the compound ratio of the decrease of the velocity and density. The quantity of water mixed with the steam and thrown into the boiler in a unit of time, must therefore decrease with the internal pressure, although the ratio of the weight of this water to that of the steam, increases. Now, as this quantity of water flowing in in the unit of time depends principally upon the size of the annular space between the exterior wall of the ajutage and the interior of the surrounding cone, it is easily seen that this space must be contracted in proportion as the pressure in the boiler diminishes.

The Academy of Sciences, of Paris, have awarded to this Injector the Montyon Prize of 1000 francs, "for the most deserving invention of instruments useful to agriculture, the mechanic arts, or sciences."

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*Notices of some of the Patents taken out for the preparation and use of the new Purple Dyes generally known as the "Mauve or Perkins' Purple, Harmaline, Violine, Purpurine, Roseine, &c.," with Remarks upon them.**

The superb and fast purple colors obtained by the action of bi-chromate of potash on aniline and its homologues, was discovered by Mr. W. H. Perkins. Dr. Hofmann's researches on aniline were doubtless the true cause of attention being drawn to that base as a substance from which results of practical importance were one day to be obtained; and in the hands of his pupil, the manufacture of aniline purple has become one of the most refined and beautiful manufactures known.

The tendency of aniline to yield colors when subjected to various processes of oxidation has long been known. Solutions of salts of aniline with the mineral acids when evaporated, generally color the edges of the basins of a red or blue tint. The power of a solution of bleaching powder to develop a charming purple tint in even the weakest aqueous solution of aniline has for many years been known, and applied in the examination of organic bases as a test for the presence of that alkaloid. This reaction has been seized upon as the foundation of a patent granted to Joshua Taylor Beale and Thomas Nesham Kirkham, dated May 13th, 1859. The following quotation from the specification will give a sufficient idea of the nature of the process:

"As examples of some of the more desirable modes of producing the improved dye according to our invention, we give the following proportions and modes of operating:—

* From the Lond. Chemical News, No. 7.

We take one measure of aniline water saturated, and add thereto one measure of acetic acid, say of five strengths, and one measure of hypochlorite of lime, of, say, specific gravity 1010. The hypochlorite should be carefully added, in order to admit of producing the particular shades of violet blues required, as shades of varying depth may be produced by increasing or decreasing the proportion of the hypochlorite. After a while the dye will become lilac, and will dye lilac of various intensities, depending on the quantity of hypochlorite of lime and water that may be mixed with the dye. Instead of adding a solution of chlorine or hypochlorite of lime to the liquor, we sometimes pass chlorine gas through the latter, carefully watching the same during the process, in order to arrest the further supply of the gas when the desired effect has been produced on the liquor."

With reference to the above we consider that any process founded upon the action of hypochlorite of lime upon aniline must be of limited application. In the first place, the presence of the bleaching powder would render it impossible for the fabric previously dyed with fugitive colors to be passed through the bath. In the next place, it would interfere in many cases with the subsequent application of other colors. But there is a more serious difficulty owing to the sparing solubility of aniline in water, consequently the dye will always be in a very dilute state, and totally useless in practice as compared with the highly concentrated solution sold by Mr. Perkins, at £6 the gallon. In the next place, even the small quantity of aniline which exists in solution will not be totally converted into dye, so that enormous volumes of fluid, involving correspondingly large vessels, will have to be employed to obtain a comparatively minute quantity of dye.

Several patents, besides that last mentioned, have been taken out for producing aniline purple. Among the substances used to oxidize the aniline may be mentioned peroxide of lead, peroxide of manganese, and the green manganate of potash.

As regards the manganese and peroxide of lead, there are two patents for the use of these substances. The first, dated May 7th, 1859, was granted to Richard Dugdale Kay. The last named patentee takes an acetate, sulphate or hydrochlorate of aniline, with excess of acid, and treats the salt with peroxide of manganese at a temperature of 212° F. until no further precipitate is obtained. The patentee also claims peroxide of lead or chloride of lime as oxidizing agents. In this process a precipitate and liquid are obtained, both of which contain coloring matter; the latter is obtained from the precipitate by digestion in dilute sulphuric acid. The liquids are then mixed together, and the coloring matter and manganese precipitated by ammonia. The precipitate is then washed and dried, and the coloring matter extracted by weak alcohol or methylated spirit.

This patent does not give any process for separating the brown or resinous impurities which accompany the coloring matter, except by so reducing the strength of the spirit as to prevent it dissolving the former. We were aware long before seeing this patent that peroxide of manganese could be used for producing the color, but the experiments made upon the subject by a distinguished Scotch chemist were, as we were informed, by no means satisfactory either as regarded the quantity or quality of the product. If the author of this process can substantiate his claim to the chloride of lime and peroxide of lead processes, he plainly takes the wind out of the sails of the patents

granted to Beale and Kirkham on the 13th, and David S. Price on the 25th of May, 1859. The latter chemist in his provisional specification claims peroxide or sesquioxide of manganese, but in his final specification he does not mention the manganese, but confines himself to the lead process. Mr. Price, by oxidizing aniline and its homologues with peroxide of lead, prepares three colors which he terms "Violine," "Purpurine," and "Roseine." For these he uses the following proportions of the ingredients:—

VIOLINE.—1 equivalent of aniline, 2 equivalents of sulphuric acid, 1 equivalent of peroxide of lead.

PURPURINE.—2 equivalents of aniline, 2 equivalents of sulphuric acid, 1 equivalent of peroxide of lead.

ROSEINE.—1 equivalent of aniline, 1 equivalent of sulphuric acid, 2 equivalents of peroxide of lead.

The substances are boiled together and filtered hot. The coloring matters are contained in solution. The two first processes do not convert all the aniline into coloring matter, the last does. It is evident, therefore, that the redness of tint increases with the extent of the oxidation. This is quite in accordance with what has been observed generally with the colors from aniline and its congeners. We must admit that while Price's patent appears the most practical of the three, we do not think his process by any means approaching in value to that due to the talent of Mr. Perkins. It is true that the colors would be yielded of considerable purity, but the expense of the peroxide of lead would be very great, and the yield probably small. Moreover there are considerable difficulties in manipulating with so dense a powder as peroxide of lead. All the machinery for agitation must be strong and kept ceaselessly in motion, or so heavy a precipitate would sink to the bottom and produce no result.

The process of Mr. Perkins has none of the disadvantages of any of the others; it is simple, practical, and yields an invariable product. It is true that it is said to require expensive and complex machinery in order to carry it out effectively; but as long as a process contains within itself the elements of success (which we do not think these new patents do), a little expense in the construction of machinery is of comparatively little moment where the final product is so valuable.

Williams's patent is for the use of the green manganate (or, as it is often incorrectly called in commerce, permanganate) of potash as the agent of oxidation. The product when the operation is properly conducted, is unexceptionable in purity and beauty. If the action be too much prolonged the color is entirely changed, and a beautiful pink or crimson color results. In fact, according to the specification, a certain amount of the pink color is always produced. In carrying out this patent, the only thing to be considered is the price of the manganate and the quantity of the product. Upon this point we are not in possession of sufficient information to speak positively.

In using these dyes much depends upon the proper selection of the mordants. Tin is the only metal which has yielded unexceptionable results. The perchloride does very well, but stannate of soda is pre-

ferred. In printing, the dye is first mixed with gum, and the colored mucilage is subsequently stirred up with the desired quantity of albumen. The printed fabric is then steamed in order to fix the color.

Messrs. W. H. Perkins and Mathew Gray (the former the discoverer of the purple, and the latter the skilful director of the great printing establishment at Dalmonach near Glasgow,) have taken out a patent for a new method of mordanting for the purple. They effect this by means of oxide or carbonate of lead. The acetate of lead is first printed on, and the fabric is afterwards passed through a bath of ammonia, or an alkaline carbonate. By this means the lead becomes fixed in the fibre of the cloth. The purple dye bath should then yield its color to the mordanted portions, to the exclusion of the other. But it is found in practice that the patterns printed in this manner are not sharp or well defined. The purple runs into those parts of the cloth which should remain white. To prevent this the goods are washed with soap and water after the fixation of the lead, before subjection to the bath; this clears the whites to some extent, but the patentees sometimes add soap to the bath itself, so as to purify the whites. But if the quantity of soap employed at first to wash the mordanted cloth has been in the proportion of one pound to twenty-five yards of cloth, they do not put any amongst the color in the bath.

It is evident that this process contains within itself sources of error. By the necessity for soaping after the mordanting, it appears that the lead does not adhere with sufficient firmness to the spot where it has been printed on; the soap is therefore to remove the feebly attached portions of mordant and prevent the color from passing its proper limits. If, however, the first soaping has been insufficiently performed the dye spreads. This can to some extent be avoided by the objectionable process of putting soap into the dye bath. The patentees also put oily or fatty matters into the bath to prevent the spreading of the color. We have reason to believe that this patent process is not successful in practice.

Petroleum Oil.

Mr. George Wilson, of London, the eminent maker of stearic acid, has greatly improved the distillation of natural petroleums, by adding to the use of superheated steam, that of a vacuum, by means of an apparatus similar to the one used in sugar-making.—*Cosmos*, March, 1860.

A Substitute for Cochineal. Fuchsine.

MM. Renard and Frank by causing certain anhydrous metallic chlorides to re-act upon the alkaloids extracted from the products of coal, or derived from azotized hydro-carbons, have succeeded in producing in a regular and practical way, a new coloring matter which they call *Fuchsine*, of great body and of incomparable richness of color and lustre. It advantageously replaces cochineal, and will entirely dethrone *murexide*. Stuffs dyed with this color have already been introduced, and have been received with surprise and admiration.

Cosmos, March, 1860.

For the Journal of the Franklin Institute.

Particulars of the U. S. Steam Sloop Pocahontas.

Hull built by U. S. Government at Gosport Navy Yard. Machinery originally built by Harrison Loring, of Boston; rebuilt at the Gosport Navy Yard.

HULL.—

Length from knighthead to taffrail,	171 feet.	
" on load water line,	154 "	
Breadth of beam, extreme,	30 "	4 inches.
Depth of hold,	13 "	6 "
Length of engine and boiler space,	30 "	
Draft of water,	12 "	
Displacement at load draft,	775 tons.	
Tonnage,	694 "	

ENGINES.—Two—Vertical direct action.

Diameter of cylinder,		33 inches.
Length of stroke,	2 feet	6 "
Diameter of shaft,		8 "
Cut-off—fixed slide—half-stroke.		
Maximum pressure of steam,	20 lbs.	
" revolutions,	70.	

BOILERS.—Two—Martin's vertical tubular.

Length of boilers,	11 feet.	
Width "	9 "	3 inches.
Height " exclusive of steam chimney,	9 "	6 "
" " inclusive "	13 "	6 "
Furnaces in each boiler,	3.	
Breadth of furnace,	2 "	5 "
Length of grate bars,	6 "	
Number of tubes (iron),	1260.	
Length of tube,	2 "	3 "
External diameter,		2 "
Grate surface,	87 sq. ft.	
Heating surface,	2251 "	
Diameter of smoke pipe,	4 "	5 "
Height " above grates,	44 "	

SCREW.—Uniform.

Diameter,	10 feet.	
Length at hub,	2 "	
" periphery,	1 "	9 inches.
Pitch,	18 "	
Number of blades,	2.	

Remarks.—During a trial at sea, March 27, 1860, speed 8 knots. Revolutions, 59. Steam, 15 lbs. J. H. W.

Effect of Pressure on Electro-conducting Power.

M. Elie Wartmann has found experimentally that the electric conductibility of copper wire is sensibly diminished by a pressure of 50 atmospheres, that this diminution increases with the pressure, and disappears when the pressure is relieved. The experiments were carried up to 400 atmospheres. These results establish a new analogy between heat, light, and electricity.—*L'Institut.*

Specification of the Patent granted to WILLIAM CLARK, *for Improvements in obtaining or extracting Quinine and the principal Organic Alkalies.*—Dated May 3, 1859.—(A Communication.)*

The several processes for the manufacture of sulphate of quinine which have been made use of or suggested to the present time are well known, and consist in the action either of alcohol, or of essences, schist oils, or of coal and other carburets of hydrogen on the raw precipitate, dried or pulverized, and producing decoction of quinquina. The several agents exhausting the precipitate more or less completely produce a sulphate of quinine of greater or less strength. The principal objections to the employment of these substances are their volatileness and the loss resulting from their use; the necessity for drying and pulverizing the precipitate, and consequently the danger and even certainty of leaving some quinine unextracted. In short, all the known processes, with the exception of the direct treatment of the bark by means of alcohol, present the grave objection of leaving a great quantity of the quinine in the mother water of the decoction, which will be precipitated at the bottom in a raw state, from which it has to be withdrawn by evaporation at comparatively great expense in relation to the result.

The improved method herein proposed, appears to be exempt from the above-mentioned defects, and also presents great advantages, which are as follows:—A decoction is obtained from the bark in the ordinary manner by means of hydrochloric or sulphuric acids; an alkali or alkaline carburet is then added, such as soda, ammonia, or carbonate of soda, until precipitation ceases; at this moment the liquor becomes entirely alkaline, care being taken that the excess of alkali be as little as possible. The liquor holding the precipitate in suspension is then boiled, and a certain quantity of solid fatty acids, such as stearic or margaric acids, added; these acids then melt and form a layer on the surface with which all parts of the liquid under the influence of ebullition come in contact successively; in this manner the quinine being dissolved in the water combines with the fatty acids, and forms with it a perfectly insoluble soap. After a certain time the precipitate becomes of a blackish color, and the alkaline liquor is transformed into quinic acid, neither one nor the other containing any trace of the quinine or cinchonine, which are entirely absorbed by the fatty acids. The liquor is then allowed to rest and cool. When the fatty acids become solidified on the surface, they are removed in the form of a cake, and then boiled with distilled water for the purpose of removing any impurities with which it may be mechanically combined. This is continued until the fatty matter yields nothing more to the pure water; it is then boiled in water acidulated with sulphuric acid, and the excess of acid subsequently saturated in the ordinary manner by means of an alkali; some dark matters will be precipitated, and after filtration a crystallized block of sulphate of quinine will be obtained by cooling, which block may be purified as in ordinary.

*From the Repertory of Patent Inventions, Feb., 1860.

It will be understood that the right is reserved of using any fatty acid, either solid or liquid, or oils which may be spontaneously acidified, or of all substances which may directly, or by a double decomposition, produce an insoluble combination of fatty acids and quinine or quinine soap. However, in practice, preference is given to fatty acids produced by the fusion of candles, which are unalterable in the atmosphere and do not mix with water, are easily separated from the precipitate, and also have the great advantage of becoming solid; the operation effected by these means is complete, very simple and rapid in execution. It will be understood that this improved process is also applicable for the extraction of alkalies from opium, morphia, codéia, &c. The operation as applied to opium is effected in a precisely similar manner as for the precipitation of quinine. It will be observed that the principal feature of the present invention is the use of fatty acids for the extraction of matters from any vegetable base, as hereinbefore described.

Specification of the Patent granted to WALTER CRUM, *for Improvements in Printing and Dyeing Textile Fibres and Fabrics.*—Dated May 23, 1859.*

My invention consists in a mode of treating gluten, and employing it in conjunction with an alkali as a mordant or intermedium for attracting and fixing certain coloring matters to cotton and other vegetable textile fibres and fabrics.

The method is to mix gluten with caustic potash or soda, or with the silicate of potash or soda; to print or otherwise impregnate the fibre or fabric with the solution or mixture so produced in the manner well known to calico printers and dyers; to subject the fibre or fabric so impregnated to the joint action of heat and moisture, and then to apply the particular coloring matter which is to be attracted and fixed.

The process I adopt is as follows:—

First, I take the gluten of wheat as it is produced in the well-known process of kneading the flour of wheat with water and washing away the starch, and I allow it to remain in a suitable vessel until it has lost its tenacious character and acquired in some measure that of a mucilage. The period at which this change takes place varies with the different qualities of flour from which the gluten is produced, and the temperature at which it is kept. It is usually sufficiently fluid after five or six days when kept at summer heat, and between that period and eight or ten days thereafter it is in the best condition to be used for the purposes of this invention.

Secondly, I then proceed to purify this mucilage by rendering the gluten which it contains again insoluble and coherent, and for that purpose I mix it with a solution of carbonate of soda sufficient to saturate the acid which has been formed in it; the point of saturation being indicated by test paper in the usual way. For ten pounds of gluten in this condition there is usually required eighteen ounces of solution

* From the Repertory of Patent Inventions, Feb. 1860.

of carbonate of soda of specific gravity 1·150. The gluten in becoming again insoluble gradually separates from the soda solution, and partially resumes its tenacious and coherent state, and the whole being shaken on a cloth, the solution passes away along with some portions of starch not previously separated. Assuming the above quantities to have been used, the gluten remaining is then to be kneaded or washed with three pounds of cold water and shaken on a cloth as before; and this washing operation is to be performed three times.

Thirdly, ten pounds by weight of the purified gluten is to be mixed with fourteen ounces of solution of caustic soda, specific gravity 1·080. The gluten immediately dissolves and forms a mucilage, which is to be diluted with water to the required thickness, as is understood by calico printers. For cylinder printing I usually add seven pounds of water.

Fourthly, when the fibre or fabric of cotton or linen has been printed or otherwise impregnated with the compound just described, and dried, it is subjected to the action of steam (or of heated air more or less moist), then rinsed in water; and,

Fifthly, dyed in a preparation of orchil in the manner well known, or in picric acid or dinitrophenylic acid, or in the coloring matter obtained from coal tar or from aniline; or the same coloring matters may be applied by printing them upon a fibre or fabric previously prepared with the glutinous mordant fixed by steam, and subsequently again subjecting the printed fabric to steam.

Although I adopt by preference for the purification of the gluten, as above described, the employment of carbonate of soda, yet I find that other substances, caustic soda, or potash or ammonia, or the carbonates of potash or ammonia, or the sulphates or phosphates of soda or potash, or common salt, or nitric acid, may be employed for reproducing the insoluble and coherent condition of the gluten; but I find the alkaline carbonates the most suitable substances. I also find that gluten may be employed without the prescribed purification, and at an earlier or later period after its separation from the starch, though not, as I believe, to the same advantage as the prepared gluten, nor with the same certainty of a uniform result. If taken at an early period, the gluten should be mixed with about a fourth of its weight of caustic soda, specific gravity 1·080, and if taken after the gluten has attained its most fluid condition, it should be mixed with about one-third of its weight of the same caustic soda, more soda being required in proportion to the length of time the gluten is kept, and in these several operations the soda may be replaced by an equivalent quantity of potash.

Having now described the nature of my invention, and the manner of performing the same, I would observe that I do not confine myself to the precise details referred to, as the same may be varied without deviating from the peculiar character of my invention; nor do I confine myself to the precise proportions given, as these may be varied with advantage, according to the condition of the gluten, which again varies with the quality of the flour from which the gluten is produced, with its own age and purity, and with the temperature at which it is kept. These are points which will readily be understood and allowed

for by any competent workman, who, when his material varies in character, has only to test it by a preliminary trial with proportions of alkali slightly varying, and to observe what proportion gives the best result on being dyed. The alkaline salts, silicate of soda or potash, in which the alkali has not entirely lost its alkaline character, and in proportions containing an equal quantity of alkali with that mentioned above, may be employed for dissolving the purified gluten, although, as I believe, with less advantage than the alkalies which I have named. And I do not claim the employment of a mixture of gluten, alkali, and coloring matter, unless such gluten shall have been purified in the manner hereinbefore described, or unless such mixture shall be used after its application to the fibre or fabric as a mordant for the coloring matters already specified.

But what I do claim is,—

The application of gluten along with potash or soda, or the silicate of potash or soda, to cotton and other vegetable textile fibres and fabrics as a mordant for attracting and fixing any of the coloring matters above stated, with which it is brought in contact after being applied to the fibre or fabric; and I also claim the treating and purifying of gluten in the manner and by the materials above described.

Translated for the Journal of the Franklin Institute.

The Screw Propeller.

A French engineer, M. Taurines, has been performing an interesting set of experiments on the effects of the screw propeller by means of a new instrument which he calls a *Helicometer;* which consists of two, and sometimes three dynamometers, each of which is composed of a series of comparatively feeble springs so that they will measure light or powerful effects with equal precision. Of the two dynamometers of the helicometers, one measures the force transmitted to the shaft of the propeller, and the other the pressure of the propeller; these two data joined to the velocity of the vessel give three of the four quantities which enter into the fundamental equation of the work done, so that the fourth may be determined. For, let P represent the force transmitted to the shaft, in kilogrammetres; the pressure in kilogrammes R, the velocity v and the co-efficient of useful effect p; we shall have the equation, $\mathrm{P}\,p = \mathrm{R}\,v$, or, $p = \frac{\mathrm{R}\,v}{\mathrm{P}}$; in which R, P, and v are given by the observations. This determination has the advantage of being independent of all hypothesis, and gives the true mechanical effect to the propeller.

The most valuable part of M. Taurines' work is the numerous applications which he has made of his helicometer to the measurement of useful effect of more than forty screws differing very much from each other in pitch, diameter, fraction of surface, and number of blades. He experimented at first on a large boat which he had built on purpose. The steam engine was of high pressure and cog-geared, the motor

wheel having 90 teeth; the pinion on the shaft did not gear directly into this wheel, but into an intermediate one, so that the pinion could be changed at will; the pinions varied by two teeth each, from 20 to 40 teeth; each stroke of the piston produced, as desired, from $2\frac{1}{2}$ to $4\frac{1}{2}$ turns of the screw. The machine preserving sensibly the same velocity. The 40 propellers, all of the common form, were of cast copper with planed surfaces and carefully verified.

The essential elements of a screw propeller are, *the pitch, the diameter, the number of blades, and the fraction of the surface*, and it was required to appreciate in turn the influence of each of these elements. In these experiments the pitch varied from 0·535 to 1·4 metres; the diameter from 0·475 to 0·640 metres; the number of blades from 2 to 6; the fraction of surface from 0·14 to 0·519.

We have not access to the five tables in which M. Taurines has given the numerical results of his experiments, in which he registered and calculated over 5000 metres (more than three miles of curves), but the following are the general conclusions:—

1. *Influence of the Pitch.*—The examination of the five groups of experiments shows that in every case, without exception, *the useful effect diminishes as the pitch increases.* Thus with screws of the same diameter and same number of blades, as the pitch increased from 0·535 to 1·4 metres, the useful effect fell from 0·66 to 0·45.

2. *Influence of the Diameter.*—The three sets of experiments on this subject show that a considerable advantage arises from the use of screws of large diameter; the useful effect is considerably increased, and the number of turns of the screw may be much reduced.

3. *Influence of the Number of Blades.*—The 4-bladed screw is always superior to the 2-bladed; but the advantage was not sufficient to overcome the other advantages of the latter.

4. *Influence of the Fraction of Surface.*—The fraction of surface may be considerably reduced without much altering the useful effect; screws having fractions 0·135 and 0·14 gave useful effects of 0·698 and 0·658. But if the fraction be too small the machine will not work so regularly; especially for screws of four or five blades the fraction of surface ought to have a certain value.

Besides these four influences M. Taurines studied the effect of the velocity of the vessel upon the resistance of the water. He tried three screws with velocities of from 1·5 to 2 metres; with the first two, the experiments were divided; that is, the movement was alternately fast and slow so as to preserve uniformity of condition. From the comparison of the numbers it is seen that the resistance increased more rapidly than the square of the velocity, and was proportional to the power whose index is 2·591.

Preparation of Chrome-Green.

When a mixture of 3 parts of boracic acid and 1 part of bi-chromate of potassa is calcined at a temperature of about 932°, there is a disengagement of water and oxygen, and a formation of a double

borate of potassa, and sesqui-oxide of chromium. This salt which is fixed at ordinary temperatures is decomposed by water into acid borate of potassa, and sesqui-oxide of chromium, which, in its nascent state, absorbs water, and forms a hydrate of a superb color. The hydrated oxide is separated from the acid salt by washing and decantation.

This method is devised by M. Guignet, of the Polytechnic School, and the resulting chrome-green is put into commerce, either as an oil paint, or as a color for printing calicoes. To make the first, it is dried and powdered; to form the second, the paste is introduced directly into the grinding mill. This color is of very great body, and of a brilliant tone, which it keeps in artificial light, and will form mixtures with the usual yellows, whose primitive purity remains unalterable.

Cosmos, December, 1859.

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*On a System of Moving Bodies.** By ALEXANDER STEPHEN WILSON.

Theorem.—If in a system of bodies moving in a straight line in free space one part of the system be made a fulcrum for projecting another part, either in a plane perpendicular to the motion of the system, or parallel to that motion, such projection shall not alter the rate of motion of its centre of gravity, nor change that centre's line of motion; and the parts projected, when they have described the resultant of the forces by which they are moved, shall be again brought by the unvarying motion of the centre of gravity, as near as before projection, to the centre of the system.

Let A B C D (Fig. 1) be a system of bodies, moving in the line M N O. Complete the parallelograms E F and F G, and also H N and N L, and draw the diagonals D D′ and D′ D″, and likewise M K and K O. If from M the part D be projected in the line D E, the part A B C shall likewise be projected in the line M H; and the two projected parts shall first be carried beyond the line of motion M N O to D′ and K respectively, and next to O, or into the relation they occupied before projection.

Fig. 1.

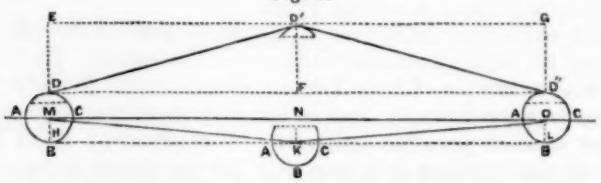

Fig. 2.

For if with the system at the point M the part D be projected in the line D E, perpendicular to the line of motion of the system, the remain-

* From the London Civ. Eng. and Arch. Jour., Dec., 1859.

ing part A B C shall by reaction be projected in the contrary direction, or in the line M H. But it is assumed that the system has a motion in space much more rapid than the motions of projection. And, by the principle of the parallelogram of forces, the resultant of D E and D F is D D′. And the resultant of M H and M N is M K. When, therefore, the system has moved to the point N, the part D will be at D′; and the part A B C at K. And because action and reaction are equal and contrary, the reciprocal projection of the two parts will leave the centre of gravity of the system unaffected in the point N, at a distance from either of the displaced parts determined by its relative momentum; while the ratio which the respective forces D E and M H bear to the force M N or D F, determines the limits of projection F D′ and N K. But it is involved in the second law of motion, that bodies must move in the line of the force by which they are moved. Now, the parts at D′ and K have been projected out of the line M N O, by which these parts are virtually moved, and to which they are as much connected at N as they were at M. For, since it is the momentum of the system which enables the projecting force to act, it is the motion of the system which impels the parts into the line of that motion. This force therefore at N, where the resultants of projection and translation in space terminate, must bring the displaced parts again down to the centre of gravity, or towards the line of the force by which they are moved. The motion of the system being the force which opposed the separation of the parts, is, necessarily, a force drawing the parts again together; or, more properly, drawing each of the parts into its own line of motion. But if the force represented by N O draws the projected parts into the line of that force, then because the part D′ is moving in the line D′ G, and the part A B C in the line K L, the parts are respectively acted on by forces moving parallel to D′ F and D′ G, and to K N and K L; and the lines into which these forces may be respectively resolved are D′ D″ and K O. Therefore, at the point O, the motion of the system has brought the projected parts again as near to the centre of that system as before projection.

Again, let A B C D (Fig. 2) be a system of bodies moving in the line M N O with a uniform rate of motion. Let the system be separable into two equal parts in the plane B D; and let a force of projection be introduced at M, acting parallel to the motion of the system. If the two parts be separated as at A B D and B C D when the system arrives at N, these two parts shall be again united by the motion of the system when the centre of gravity arrives at O.

For if the act of projection takes place at M, it is clear that in one part the force of projection will be added to the motion of the centre of gravity, and in the other subtracted from it; so that when that centre arrives at N, one part of the system will be at A B D and the other at B C D. The half of the system A B D will be made to move slower than the uniform rate of the centre; and because it was the reaction or resistance to increased motion of the other half, B C D used as a fulcrum, which enabled the force of projection to lessen the motion of A B D, the amount of motion subtracted from A B D must be precisely the amount

added to B C D; and therefore, by the equality of action and reaction, B C D will move as much faster than the centre of the system as A B D moves slower; and the centre will thus remain unaffected. But the two parts thus mechanically separated are still dynamically connected with the centre of motion as much as before separation. The position of the two parts at N are the total resultants of the force of projection, combined with the uniform motion of the centre. The force of projection, in respect of both parts, is opposed by a contrary force. A B D in coming from M is moving slower than the motive force of the system; but, being part of that system, the motive force is constantly acting against the retarding force of projection, and therefore constantly accelerating this part, until at A B D it momentarily possesses the same rate as the centre N. Conversely, the part B C D is, during the same time, moving faster than the centre of the system, which consequently necessitates its retardation, because the slower motion of the centre of the system is acting against the force of projection, until at B C D this part likewise passes through the point of equal motion with the centre N. But at N, the part A B D possesses the uniform rate of the system, *plus* the force of acceleration which brought it up to that rate; and the part B C D possesses the uniform rate of the system, *minus* the force of retardation which brought it back to that rate. Therefore, at N, the relative motions of the parts will become reversed,—A B D will now move faster than N and B C D slower, because A B D possesses the rate of the system, *plus* its acquired force of acceleration, therefore it must move faster than N; and because B C D possesses the rate of the system, *minus* its acquired force of retardation, therefore it must move slower than N. But because A B D, after passing its position at N, is moving faster than the centre of the system, and B C D slower, they must meet in the point O. And because the part A B D will then have just as much more motion than O, or than the centre of gravity, as B C D has less, the uniform rate of the centre of the system will still remain unaffected. For at every moment, the motions of the parts added together, the one being positive and the other negative, give the normal motion of the system. Therefore, the progressive motion of a system of bodies will cause the parts of the system separated in a line parallel to that motion again to meet.

Corollary.—It follows from these two cases, which are susceptible of an infinite variety of combinations—depending upon the angle which the plane of projection makes with the plane of motion—that since it is the motion of the system which brings the projected parts together, the force of projection displacing the parts is a force exerted, not to overcome any inherent attraction in the parts, but to change the direction of motion in these parts. Therefore, if the system were at perfect rest, there could be no projection, since there would be no motion to create a fulcrum. Also, the faster a system is moving, the greater will be the weight or momentum of its parts, since the weight is not an inherent quality of matter, nor a result of any inherent power in matter, but simply a result of motion. It likewise follows that, as the planets are systems of moving bodies, the motion of projectiles on their

surfaces, and the whole phenomena of weight—differing in value, as they must do, with the respective rates of each planet—are solely referable to the motions of these systems. From which it is easily deducible, that *the motion of the terrestrial system is terrestrial gravitation.*

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*On the Application of Superheated Steam in Marine Engines.** By the PRESIDENT of the Institution of Mechanical Engineers.

An opinion in favor of superheating the steam supplied to steam engines has long existed, and it has been maintained by many that important advantages might be obtained from this principle; though until recently but little has been effected in its practical application, and much doubt has been felt as to its advantages proving sufficient to lead to its general adoption. The development of the principle has probably been checked by exaggerated ideas being entertained respecting its advantages on the part of its earlier advocates; and also by somewhat incorrect views of the action of superheated steam, leading to attempts to carry the superheating to an excessive degree, thereby involving much extra risk of failure and stoppage of the apparatus, and tending to discourage further pursuit of the object.

Superheated steam seems to have been definitely tried about 27 years ago by Mr. Thomas Howard, of Rotherhithe; but in this case the boiler or vaporizer was dry, and only enough water was injected at each stroke of the engine to supply the necessary quantity of steam. It would appear from the experiments made, that very considerable economy was effected; but although the apparatus thoroughly established the principle, it was too delicate in its construction, and was for this reason given up. Mr. Howard appeared to be fully alive to all the advantages of the system, and always expressed his opinion that there was a loss of 30 per cent. in an ordinary steam engine, which would be recovered by superheating the steam. Soon afterwards the late Dr. Haycraft, of Greenwich, took up the subject and advocated it strongly, being convinced that great advantages would be obtained by superheating the steam in engines; and he used to express his confidence that the time would come when the principle would be generally adopted, and that a saving of 30 per cent. in the consumption of fuel would be thereby effected.

The importance of the principle was first impressed upon the writer many years ago by Mr. Howard, and afterwards by Dr. Haycraft, with both of whom he was very intimate; and he has become satisfied from the results of experiment and observation that important advantages in economy of fuel may be obtained from the system; the main question to be settled being whether it involves any serious practical objection from complication of apparatus, risk of derangement and failure, or difficulty in lubrication of the engine. The recent trials he has made on a large scale have led him to the conclusions:

That an advantage can be obtained from the use of superheated steam amounting to an economy of fuel of from 20 to 30 per cent. in marine engines;

* From the Lond. Artizan, March, 1860.

That a moderate extent of superheating enables all the important advantages of the plan to be obtained;

And that apparently nothing objectionable is then necessarily involved from extra wear and tear, risk of failure, complication of apparatus, or difficulty in lubrication.

The real source of advantage in employing superheated steam, appears to be in preventing the presence of any water in the cylinder of the engine, and insuring that the cylinder shall never be occupied by anything but pure steam; making it a real steam engine, instead of one working with a mixture of water and steam. In all condensing engines the interior of the cylinder being open to the condenser during half the time of each revolution of the crank is in communication during that time with the low temperature of the condenser, or about 110°, when the vacuum is 13½ lbs. per inch below the atmosphere, or 27 ins. of mercury. There is consequently a rapid radiation of heat from the sides and end of the cylinder, cooling down the whole mass of metal. The steam admitted into the cylinder in the next stroke, at a temperature of 206° if at 20 lbs. per inch above the atmosphere, coming in contact with these cooled surfaces, heats them up again, being robbed thereby of a portion of its heats; and the consequence is the deposit of a quantity of water in the cylinder, from condensation of an amount of steam proportioned to the quantity of heat imparted to the metal of the cylinder. A portion of this water in the cylinder may be evaporated again into steam towards the end of the stroke, by carrying the expansion of the steam down to a sufficiently low pressure; but even then its effective value as steam in propelling the piston will have been lost during all the previous portion of the stroke. The engine must, in fact, be looked upon as only in degree better than Newcomen's atmospheric engine, in which the whole of the steam was condensed in the cylinder at each stroke; and the advantages of Watt's great invention of condensation in a separate vessel are not fully realized until this serious defect is removed. Now, if as much heat be added to the steam by superheating it before entering the cylinder as will supply the amount of which it is robbed by the cylinder, it will remain perfect dry steam throughout the stroke, and not a drop of water will be deposited. This the writer believes to be the mode in which the superheating of steam acts in producing a saving of steam and consequent economy of fuel by preventing the extensive waste of steam that ordinarily takes place; and this indicates the extent to which the superheating can be carried with any great advantage. The writer believes that an addition of 100° of heat to the temperatures of the steam insures the accomplishment of the desired object with steam at 20 lbs. per inch above the atmosphere, as used in marine engines; the steam is thus heated from 260° to a temperature of 360°, and is then only about as hot as the ordinary high pressure steam of 120 lbs. per inch, used in locomotive engines.

The plan of superheating the steam before entering the cylinder is a simple and eligible mode of obtaining the desired object, and appears also to be preferable to a steam jacket. For when the steam is supplied

to the jacket from the same boiler as the cylinder, the supply of heat to the metal will be slower than in using superheated steam, owing to the difference of temperature being less; and to carry out the object fully, requires the steam in the jacket to be superheated, and the cylinder covers to be also jacketed, since in the short stroke marine engines, where the diameter is nearly double the length of stroke, the area of the two covers or ends equals that of the sides. But even then the application of the heat by the steam jacket is outside the cylinder, and the heat is delayed in its action by having to pass through the thick metal; whereas by introduction of superheated steam into the interior of the cylinder, the object is accomplished in the most direct manner, by heating the surface with which the steam comes in contact, and even a momentary chill of the steam down to the condensing point is entirely prevented. By superheating the steam with the waste heat of the smoke box, not otherwise usefully available, all this effect is obtained without cost; but with the steam jacket the heat used has to be supplied from the boiler. An important practical advantage attending the use of superheated steam is obviously that all objectionable joints of steam jackets are avoided; and the cylinder being felted and lagged the same as the steam jacket, there will be no more loss of heat by radiation from the outside.

The mode of superheating the steam may be varied in many ways: a general principle to be aimed at being to make use of the waste heat for this purpose after leaving the boiler, so as to accomplish the superheating without any cost of fuel; and to place the apparatus where it will not be exposed to injury from too great heat. The superheating apparatus has generally been placed in the smoke box or up-take flue in marine boilers, and has consisted of faggots of tubes or coils of pipes for the purpose of obtaining the required extent of heating surface within a limited space.

The accompanying drawings show the arrangement used by the writer and employed in a recent extensive trial of the plan in the *Valetta* steamer of the Peninsular and Oriental Company, of 260 nominal horse power, running between Malta and Alexandria. In the smoke-box of each boiler are placed two horizontal faggots of tubes, forming the superheating apparatus, each consisting of 44 wrought iron tubes, 2 inches diameter inside, and 6 feet 3 inches long, placed in vertical rows with clear spaces between them horizontally for allowing ready access in cleaning the boiler; these spaces are left opposite each row of tubes in a tubular boiler, but in the present case the boiler is constructed with Mr. Lamb's vertical flues in place of tubes. The superheating tubes are fixed into three flat chambers, which are made of wrought iron welded at the corners, and closed each with a single flanch joint. The steam is supplied from the boiler to the centre chamber through a stop-valve and pipe, and is taken off from the end chambers by stop-valves communicating with the steam pipes leading to the engines. The steam is thus made to pass through the superheating pipes on its way to the cylinder, and becomes superheated by taking up a portion of the waste heat escaping from the boiler flues

before reaching the up-take flue leading to the chimney. The steam pipes have also the ordinary direct communication with the boiler through second stop-valves, so that the whole superheating apparatus or either half of it can readily be shut off and disconnected at any time if desired.

The vessel has made two trips from Malta to Alexandria and back, a total distance of 3276 miles, with the superheating apparatus; and then two of the same trips without the apparatus, but with no other alteration. The result was a saving of 20 per cent. in the consumption of fuel, although the men were not experienced in the management of the apparatus; and there appears every reason to believe that when the apparatus has been a little longer time in use, the saving will be still greater. The main object kept in view in the detail of construction of the apparatus was to insure a simple and durable plan that would not require any repairs for a long time; and for this purpose the superheating tubes were made a thorough mechanical fit, and free from strain of expansion tending to make them leaky. The wrought iron tubes are $\frac{3}{16}$ inch thick, and have thick ends welded on to them, as shown half full size; these are turned down to a square shoulder, and all correctly to the same gauge for length, and fitted tight into the holes of the tube plate, which is also planed on the face and accurately bored; the tubes are then pressed into their places all at once by the plates being drawn together with screws, and are made steam-tight by the fit alone; the ends of the tubes are then expanded as shown. The total area of superheating surface including the wrought iron boxes is 374 square feet in each of the two boilers, giving a proportion of $2\frac{3}{4}$ square feet of superheating surface per nominal horse power, the engines being of 260 nominal horse power, and the boilers having a heating surface of 19 square feet per nominal horse power; this proportion appears from the writer's trials to be sufficient for superheating the steam to the extent that is desirable. The apparatus has not leaked or failed in any way during the time it has been at work, and appears likely to prove very durable.

The heat employed for superheating the steam is taken entirely from the waste heat after leaving the boiler, which would otherwise have escaped by the chimney; and this abstraction of heat from the smoke-box, together with the screen of superheating tubes, shielding the smoke-box doors, has produced a marked effect in keeping the stoke-hole uniformly much cooler when the superheating apparatus was applied than without it. The temperature of the steam is constantly indicated by a thermometer, which is fixed in a small cup projecting into the interior of the copper steam pipe, and containing a little mercury at the bottom in which the bulb of the thermometer is immersed. The fluctuations of this thermometer indicate very delicately the variations in temperature of the steam; and the mercury in the thermometer is affected considerably by the changes in firing, falling when the fire-door is opened for fresh firing.

In this arrangement no additional space is required for the superheating apparatus, the whole being contained within the ordinary

smoke-box, without any alteration of the boiler or any interference without its construction; the only external addition being the stop-valves communicating with the apparatus. This apparatus can therefore be readily applied to ordinary marine boilers, without requiring any alteration beyond the extra connexion and stop-valves, and without interfering with any of the arrangements of the engines or boilers; and the important saving of 20 to 30 per cent. of the fuel can be thus effected, without incurring any risk of trouble or delay from the superheating apparatus. In case of any failure of the apparatus, it will be seen that it is only necessary to shut one set of stop-valves and open the other.

The writer would observe in conclusion, that there are various plans adopted by different engineers for superheating the steam, many of which have been applied by the inventors, and in many cases with considerable success. Amongst these may be named those of Mr. Wethered, Mr. Partridge, and Mr. Pilgrim, who have done much lately to establish the value of the system by practical application.

The CHAIRMAN observed that the trial of superheated steam had been determined upon in the case of the vessel described in the paper, after the completion of the boilers; and the time being very short for fitting up the apparatus, he had to devise a means of accomplishing it without interfering with the work already done, and had consequently adopted the plan shown as the simplest arrangement and the quickest for construction. The apparatus was simply a work of repetition in the parts, the superheating tubes being all exactly alike, and fitted by machine work; the great object in view was to insure against any risk of interfering with the efficiency of the vessel by failure or accident with the new apparatus, and to arrange the whole so that it could be readily disconnected and the work carried on exactly the same as before the application of the superheating apparatus.

He had not had an opportunity of trying any experiments with it himself, and did not consider the trial at present made a fully conclusive one as to results; but the vessel had been three months working since the apparatus was applied, part of the time without the apparatus for the purpose of comparison, and a pretty satisfactory proof of its success was that the engineers were very glad to get the apparatus in again; and there was found to be a reduction of 20 per cent. in the consumption of fuel when the apparatus was used. He had tried one approximate experiment with the apparatus before the vessel left this country, by graduating the opening of the injection cock of the condenser, and observing the extent of opening required for working with and without superheated steam; and he found that little more than two-thirds of the quantity of injection water was required when the steam was superheated, showing that a much smaller quantity of steam must have passed through the cylinders into the condenser, with a corresponding saving in consumption of fuel in the boilers.

A difficulty was anticipated at first in keeping the joints all permanently tight throughout the apparatus, but none whatever was experienced, and there had been no leak since it was put to work; the

tubes were all made a thorough mechanical fit in the tube plates so as to be perfectly steam-tight, and they were not exposed to any strains from expansion and contraction, as the end chambers were free to move with the tubes, and the whole was of one material. It was an important point in anything of the kind to have a thorough good job made at first, and several of the attempts at applying superheated steam had been unsuccessful from failure of the apparatus in mechanical points, causing objections to be felt to superheating that did not really apply to the principle itself, but only to defects in the mode of carrying it out.

The CHAIRMAN replied that the pressure was kept the same, as it would be regulated in both cases by the load on the safety valves, which was not altered; the effect of the superheating could therefore be only to increase the volume of the steam by the expansion due to the increase of temperature, so that a greater quantity of steam at the same pressure would be supplied to the engines from the evaporation of the same quantity of water in the boilers.

Mr. E. A. COWPER observed that the pressure did not vary with the temperature; and whatever superheating took place, the effect could be only an increase in the volume of the steam and in its temperature, as it would be impossible for any difference of pressure to exist in the superheating apparatus, except, indeed, a slight diminution of pressure that would arise from the resistance of the small tubes to the passage of the steam. The first effect of the superheating would be the evaporation of all the moisture in the steam, as steam always left the water in a boiler in a more or less wet or damp state, from the mixture of minute particles of water with it, even when there was no sensible priming; it would then become perfect or dry steam, but at first would not be raised at all in temperature; but when the superheating was carried beyond that point, the temperature of the steam would be raised by all the heat added, and its volume proportionately increased, causing an increase in the total quantity of steam supplied at the same pressure and from the same evaporation of water. Steam was expanded by increase of temperature at pretty nearly the same rate as air and other gases: and since air at 32° was doubled in volume by an increase of temperature of 480°, steam at 20 lbs. per inch or 260° would be doubled in volume by 708° increase of temperature ($480° + 260° - 32° = 708°$); and a rise of a hundred degrees from 260° to 360° would consequently increase its volume $\frac{1}{7}$th, causing an equal saving in consumption of fuel when the superheating was effected by using the waste heat of the smoke-box. As the specific heat of steam was only about $\frac{3}{4}$ths that of air, steam would require only $\frac{3}{4}$ths the quantity of heat to be supplied to it to produce the same rise of temperature; and partly for this reason steam was now used instead of air in caloric engines, since the same effect of expansion was thereby obtained with so much less supply of heat.

There was no doubt that in cylinders without steam jackets condensation of a portion of the steam took place at the beginning of the

stroke, and a partial re-evaporation at the end, on account of the metal of the cylinder being colder than the fresh high pressure steam entering from the boiler, but hotter than the expanded steam in the cylinder at the end of the stroke; since the whole metal of the cylinder could not change in temperature twice in each stroke (though the interior surface must do so), the temperature of the cylinder and piston must be an average of the temperature of the whole of the steam coming in contact with them. He had tried a direct experiment suggested to him by Mr. Appold, namely: fixing a glass gauge tube in communication with the interior of the cylinder, the outer end of the tube being closed; at the beginning of the stroke, the interior of the glass became quite dull with moisture, from condensation going on in the cylinder; but towards the end of the stroke, the moisture was entirely evaporated and the glass became clear, showing that there was perfectly dry steam in the cylinder by that time. The cylinder was, in fact, a partial condenser at the beginning of the stroke, and a boiler at the end of the stroke; and if it were not for this boiling off of the condensed water at the end of the stroke, the cylinder would soon get very nearly to the temperature of the steam.

In an expansion engine without a steam jacket he had found by a comparison of the actual indicator figures with the theoretical figures which ought to have been obtained if no condensation had taken place in the cylinder, that the loss of power when cutting off the steam

at $\frac{3}{7}$	stroke	amounted to a loss of	11·7	per cent.
" $\frac{1}{5}$	"	"	19·6	"
" $\frac{1}{9}$	"	"	27·2	"
" $\frac{1}{11}$	"	"	44·5	"

But when the cylinder had a steam jacket supplied with steam direct from the boiler, he found the actual indicator figure almost exactly corresponded with the theoretical figure, except that at the end of the stroke it was raised a little, about $\frac{1}{2}$ lb. in pressure above the theoretical line, in consequence of the superheating of the expanded steam from the higher temperature of the metal of the cylinder. With steam in the jacket of the same pressure as that in the boiler he did not think there could be any condensation in the cylinder; for all that was requisite to prevent this was to keep up the metal of the cylinder at the temperature of the entering steam, by supplying the heat abstracted by exposure to the cooler steam during expansion, and that lost by radiation, which was very small in a well lagged cylinder; the piston ought to have non-conducting surfaces or plates, and the cylinder ends should have steam jackets.

He was very glad the important subject of superheating steam had been so well taken up in the interesting paper that had been given by the President, and was confident that a still higher saving of fuel than the 20 per cent. mentioned in the paper would ultimately be effected by that means.

*On the Production of the Purple and Rose-red Murexide Colors in Cotton Printing.**—By Dr. Von Kurrer.

Murexide may be used in stuff printing, either in a powdered or pasty state. It need neither be chemically pure nor crystallized, because in such conditions it is too high in price.

A. *Printing with the Color.*—In 72 pounds of boiling water, 24 pounds of crystallized nitrate of lead are dissolved; and when the solution has cooled to 144° F., 5 pounds of dry, powdered, or 15 pounds of pasty murexide are dissolved in the fluid, and afterwards 36 pounds of finely powdered gum; after which the whole is passed through a handkerchief or a fine sieve, and left to cool, in which state it may be employed either for hand or roller printing.

After printing, the stuffs are hung up in a damp place until the impressed part feels soft, when the purpuret of lead is fixed upon the fibres by means of gaseous ammonia. This is best effected by hanging the stuffs in a hermetically closed chamber, such as is used for the sulphuring of woolen and silken tissues, by means of sulphurous acid. In place of the sulphurous acid produced by the combustion of sulphur, in this case gaseous ammonia is evolved from caustic lime and muriate of ammonia.

B. *Passage of the Stuffs through the Sublimate Bath.*—The pieces of stuff treated with gaseous ammonia are now passed through a bath containing in 1500 pounds of water, 2 pounds 11 ounces of corrosive sublimate (bichloride of mercury), previously dissolved in water.

In this bath each 3 pieces, of $\frac{6}{4}$ wide and 60 Brabant ells long, united together, are passed backwards and forwards; then for each following 3 pieces, 3 ounces of sublimate dissolved in water, are added. It depends on the pattern whether a greater or less number of pieces can be passed through the heated bath.

Light patterns enable 30 pieces of stuff of the above dimensions to be treated in the same bath; whilst with heavy designs a fresh bath must be prepared after 20 pieces have been treated.

As soon as each three pieces have passed through the sublimate bath, they are hung in flowing water until the pieces are collected, when they are passed together through the acetate of soda bath in an ordinary dye trough.

C. *Acetate of Soda Bath.*—This consists of 3000 pounds of water, into which 1 pound of acetate of soda and 1 pound of muriate of ammonia have been stirred.

In this bath 10 pieces of stuff attached to one another are passed to and fro over the *harpel* for twenty minutes, then washed clean in running water, freed from water in the wringing apparatus, and dried cold.

In the same bath, furnished with 1 pound of acetate of soda, but with no muriate of ammonia, 10 pieces of stuff are again treated.

In this way prints of the most brilliant purple-red color are produced. For pale gradations, in order to produce patterns in these dif-

* From the Lond. Chemical News, No. 2.

ferent red shades, namely, dark red, middling, and pale rose-red, the normal color for the two latter gradations receives a proportional addition of pure gum-water.

Cotton stuffs printed with murexide colors may be soaped without injury at 144° F.; the color also perfectly resists chlorine in the machine without any alteration; on the other hand, it is destroyed by hot aqueous vapors, and it is therefore impossible to combine murexide with the ordinary steam colors, such as green, blue, yellow, &c.

In cotton stuffs dyed with a single murexide red color, the ground color may be destroyed in particular spots, partly by oxidizing and partly by deoxidizing agents, and thus illuminated prints of the most beautiful and various patterns may be obtained. Thus by printing with acid zinc salts, orange figures are produced.

Dark grey figures are obtained by printing with protosalts of tin. Murexide printed upon medium pale-blue grounds produced with indigo, furnishes a remarkably fine violet. Stuffs dyed yellow with yellow vegetable pigments, receive figures of a Turkey-red color when printed on with murexide.

Silken and woolen fabrics dyed of a uniform red with murexide, may be bitten with yellow by means of picric acid, when the latter is mixed with an acid capable of decolorizing murexide. In the same way other active substances may be used for printing various figures of different colors.

D. *Preparation of Murexide Plate-printing Red.*—For the plate-printing of cotton fabrics, murexide will also be advantageously employed, when to 1 quart of the above-described purple color are added 2 ounces of bichloride of mercury, and 2 ounces of acetate of soda, each dissolved in half a pint of water. The stuffs printed with this color are hung up for three to four days, and then watered in the same way as in ordinary plate-printing. Murexide, however, can only be printed with wooden blocks, because brass decomposes the bichloride of mercury, and changes the color; this is also the case in roller-printing.—*Polytechn. Centrallblatt*, 1859, p. 337.

Medals in Alloys of Platinum and Iridium.

M. Pelouze presented to the Academy of Sciences at Paris, in the name of M. Jacobi, medals of different sizes struck in alloys of platinum and iridium, fused at the laboratory of the *Ecole Normale*, by the process of MM. Deville and Debray. The alloys contained respectively 20, 10, and 5 per cent. of iridium. According to the declaration of M. Jacobi, they were rolled cold and without annealing, with great ease, and presenting the characters of the most ductile metals. Under the press they take a polish equal to that of coins; and the alloys rich in iridium, showed a hardness rather greater than that of gold of 0·916. This hardness is proportioned to the quantity of iridium, as is also the resistance of the alloy to aqua-regia, which becomes almost perfect when the quantity of iridium reaches 20 per cent.

Among the specimens laid upon the table of the Academy were two

medals, one of 63 mm. (2·5 ins.) diameter, bearing the effigy of the Emperor Nicholas; the other 41 mm. (1·6 ins.) in diameter, with the head of the Emperor Alexander 1st. These medals were struck in a platinum ore from the mines of Nischny-Tagilsk belonging to Prince Demidoff, and brought by General de Rachette. The ore fused alone by the method of MM. Deville and Debray gave an alloy, according to the analysis of M. Deville, of Platinum 92·6, Iridium 7, Rhodium 0·4. It was worked very easily, and gave a relief of 5 mm. (0·2 inch), which is greater than has ever been attempted with pure platinum. Their relief was remarkably uniform.

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Pauvert's Method of Making Steel.

In the crucible, fragments of any kind of iron are cemented by means of a thorough mixture (or concentrated solution) of oxide of iron or manganese; common charcoal, fat, or resin, and an alkaline or earthy matter, such as potassa, soda, lime, or alumina, either in the condition of an oxide or as a salt. The carbon, impregnated by the oxides or salts, is no longer attacked by the air, and combines with the iron; the metals of the alkalies or alkaline earths, under the higher temperature, and in contact with carbon or iron, purify the steel by absorbing in their nascent state the phosphorus and other foreign metalloids.

Cosmos, January, 1860.

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*On the Comparative Value of certain Salts for rendering Fabrics non-inflammable: being the substance of a Paper read before the British Association at Aberdeen.** By F. Versman, F. C. S., and Alphons Oppenheim, Ph. D., A. C. S.

Women have a right to complain that while men have expended an immense amount of ingenuity in protecting themselves from one element—witness the enormous number of patents for rendering fabrics mostly employed for male garments *waterproof*—they have done very little to protect women from the more dangerous and domestic element —fire. We are happy to see that something has been done to wipe away the reproach; and it ought to be known that it has been done at the command of Her Majesty, at whose request the Master of the Mint employed the authors of the above paper to make experiments, the use of the royal laundry being granted for the purpose. Here, and at other places, the authors tried every salt they could think of, and some salts which few persons would ever have dreamt of employing. Of the substances used, however, two only seemed to fulfill all the purposes required. These are sulphate of ammonia and tungstate of soda; but as both of these salts are soluble, the difficulty of *fixing* an anti-inflammable substance in a fabric has yet to be overcome. For laundry purposes only the tungstate of soda can be recommended, inasmuch as the sulphate of ammonia sometimes produces brown spots like iron-moulds, when the fabric is ironed. The tungstate, however, offers one difficulty, viz: the formation of a bitungstate of little solubility, which

* From the Lond. Chemical News, No. 2.

crystallizes from the solution. To obtain a constant solution, a small per centage of phosphate of soda must be added. "The best way of preparing a solution of minimum strength is as follows:—A concentrated solution of tungstate of soda is diluted with water to 28° Twaddle, and then mixed with 3 per cent. of phosphate of soda. This solution was found to keep and answer well, and has been introduced into Her Majesty's laundry." We think Her Majesty would be pleased if the authors were to inform her subjects exactly how this solution is used in her laundry; and we shall be happy to be the medium of the communication. Appended to the paper are tables, showing the smallest per centage of salts required in solution for rendering muslin non-inflammable, from which we learn that of crystallized tungstate of soda, 20 per cent., and of anhydrous, 16 per cent. are required; and of crystallized sulphate of ammonia 7 per cent., of anhydrous 6·2 are wanted.

New Telegraph Line.

We copy from the *Cosmos* the project of a new telegraph line to connect Europe and America; giving for the information of our readers the intermediate stations as we find them in the original, so that if any of them should wish to correspond with any one or more of them, he may prepare his dispatches.

"The line leaves Europe by the ordinary road to Siberia, crosses the Oural Mountains near Ickaterinbourg; passes from the Oural to the Sea of Okhotsk by Tobolsk, Narym, Yenisseisk, Iarbinskäia, Yakoutsk, Okhotsk; passes northward and reaches Behring's Straits by Tapuisköi, Alansk, Anadyrsköiost; crosses the straits by a submarine cable of about 100 kilometres (62 miles); traverses diagonally Russian America; then passing down the coast penetrates into New Britain, which it traverses for 700 kilometres (435 miles); enters the northern part of the United States, traverses Oregon, and reaches the civilized parts of the United States, (*which begin at Westport,*) under the protection of the forts Wala-wola, *Hell*, Laramie; from Westport, *the line follows the road from California to New York* by Jefferson, St. Louis, Columbus, Wasinghton, Baltimore, Philadelphia, and *finally* reaches New York, its point of destination. Three great branches are to be taken from Tobolsk in Siberia, to India by Turkestan; from Yakoutsk, also in Siberia, to China and Pekin; and from Astoria in the United States, to San Francisco. The trunk-line will have five wires, and so will the branches; two for messages from America to Europe; two for those from Europe to America, and one auxiliary, (*fil de secours*, which will probably be much wanted. ED. J. F. I.)

"The length of wire will be 32,000 kilometres (19,890 miles), and will require ten million kilogrammes (10,000 tons) of galvanized iron wire of 3 millimetres (0·118 inch) diameter; 350,000 preserved posts, and two cables, one of 100 and the other of 50 kilometres, (62 and 31 miles). The cost of establishment may be estimated at 30,000,000 francs, ($6,000,000,) and the annual expenses 7,000,000, ($1,400,000.) M. Jousselin thinks that he does not exaggerate the annual receipts at 9,000,000 francs, ($1,800,000,) and he consequently

believes that the undertaking will be really lucrative. (Six per cent. on the first cost at this estimate.)

"*The only grave objection* to this gigantic project, or the only serious fear we have for it is the crossing of Russian America, a country desolated by the ice of an eternal winter, and inhabited sparsely by demi-savage tribes."—*Cosmos*, January, 1860.

To this we have to add one fear, and one regret. The regret that the projectors have not added another branch to run from Behring's Straits along the southern shore of the Arctic Ocean, and up Smith's Sound; by means of which, we might constantly receive news of our whalers and Arctic Expeditions—besides the advantages in the coming observation of the Transit of Venus—the fear, that somewhere else along the route may be found some small additional tract of a few square miles, where the winter is as nearly eternal as in Russian America, and where the tribes are nearly as savage without being as sparse.

When this line is finished, our "old country" immigrants, meditating thoughtfully on the names of the places through which it is said to run, may find the realization of the old proverb, that "the longest way round, is the shortest way home." ED. J. F. I.

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*An Improved Means of Giving Increased Strength to Paper.**

By THOMAS TAYLOR.

The invention consists in soaking paper (either sized, unsized, or partially sized) in a concentrated solution of neutral chloride of zinc, either warmed, or at the ordinary temperature of the air. The solution must have the specific gravity of 2100, or thereabouts, when it will have the consistence of syrup. The paper to be treated must be immersed in, or floated on, the solution until it is fully saturated; it is then removed and washed with water. If it is desirable to retain a portion of the zinc in the paper, it is, after being partially washed, immersed in a weak solution of carbonated alkali, and then thoroughly washed in water. After this treatment it will be found that the paper is more or less changed, has contracted in volume, become more dense, less porous, and much stronger. When it is desired to produce a more complete change, the solution must be heated, and the temperature may be varied from 80° or 90° F. to 212°, according to the effect desired. The change is completed when the paper becomes swollen, and apparently dry, as well as opaque and flaccid. If sheets of paper saturated with the solution be pressed together and ironed, they will become permanently united. In some cases the patentee dissolves cotton fibre, starch, dextrine or gum in the solution of chloride of zinc, or he adds the chlorides of tin, calcium, or magnesium; but the paper is always submitted to a thorough washing with water.

Paper thus treated, assumes more or less the toughness, semi-transparency, and general appearance of parchment.

* From the Lond. Chemical News, No. 2.

Our readers will remember that Mr. Gaine produced the same effect on paper by immersing it for a few seconds in oil of vitriol diluted with half its volume of water. The change in both cases is no doubt essentially molecular. We should like to know whether the whole of the chloride of zinc is removed in the washing.

Copying-Paper.

Copying-paper into the body of which a certain proportion of proto-sulphate of iron (copperas) has been introduced either during the manufacture or afterwards, by passing it between rollers covered with felt impregnated with a solution of salt, is much more advantageous in use than the common paper. A letter written with common ink containing an infusion of nutgalls, or having the tanno-gallate of iron for its base, and covered with the above copying-paper gives, by means of the press, a perfect fac simile. If a little sugar or pyro-gallic acid is added to the ink, a good copy may be had by pressing lightly the copying-paper upon the latter without the use of the press: taking only the precaution to interpose between the hand and the sheet of copying-paper, another sheet of oiled paper over which the rubbing must be done.—*Cosmos*, January, 1860.

Steel.

By incorporating into melted steel from 2 to 5 per cent. of Tungsten, there is obtained a steel which is very dense, hard, and strong; admirably fitted for the manufacture of tools. The instruments made with this Tungsten steel are said to keep their temper four times as long as usual.—*Cosmos*, March, 1860.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By James A. Kirkpatrick, A.M.,

Professor of Civil Engineering in the Philadelphia High School.

March.—The month of March, this year, was remarkably mild. The temperature was 3½ degrees above the average for the last nine years, and the daily changes less than usual. The quantity of rain that fell was only half the average, and five inches less than in March of last year. March commenced with rain, which fell in showers on seven days of the month.

On the 9th and 10th, snow fell in large flakes, which melted as they fell. This was probably the last snow of the season.

The coldest day of the month was the 10th, of which the average temperature was 30·8°. The lowest degree reached by the thermometer was 25° on the 14th.

The warmest day was the 31st; mean temperature, 58·8°. The temperature was also highest on the same day, reaching 73°.

There were but three days of the month entirely clear or free from clouds at the hours of observation, and three days on which the sky was entirely covered with clouds.

The mercury stood highest in the barometer on the 16th, reaching

30·224 inches. It fell lowest on the 23d, when it stood at 29·499 inches.

A Comparison of some of the Meteorological Phenomena of March, 1860, with those of March, 1859, and of the same month for nine years, at Philadelphia.

	March, 1860.	March, 1859.	Mar. 9 years.
Thermometer.—Highest,	73°	70°	75°
" Lowest,	25	20	4
" Daily oscillation,	18·30	16·90	15·20
" Mean daily range,	5·40	6·00	6·10
" Means at 7 A. M.,	38 15	41·77	35·72
" " 2 P. M.,	52·34	55 31	47·34
" " 9 P. M.,	43·71	47 27	40·62
" " for the month,	44·73	48·12	41·23
Barometer.—Highest,	30·224 in.	30·360	30·522
" Lowest,	29·499	29·215	29·158
" Mean daily range,	·133	·250	·191
" Means at 7 A. M.,	29 829	29·777	29·845
" " 2 P. M.,	29·757	29 735	29·789
" " 9 P. M.,	29 795	29·762	29 821
" " for the month,	29·794	29·758	29 818
Rain and melted snow,	1·323 in.	6·503	2·566
Prevailing winds,	N. 79° W. ·224	S. 67° W. ·234.	N. 77° W. ·310.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, April 19, 1860.

John C. Cresson, President, in the chair.
John Agnew, Vice-President.
Isaac B. Garrigues, Recording Secretary. } Present.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Society and the Royal Astronomical Society, London; de la Société d'Encouragement pour l'Industrie Nationale, Paris; the K. K. Geologischen Reichsanstalt, the K. K. Geographischen Gesellschaft, and the Oesterreichischen Ingenieur-Vereins, Vienna, Austria; L. A. Huguet-Latour, Esq., Montreal, Ca.; Joseph Bennett, Esq., Brooklyn, N. Y.; the State Lunatic Asylum, Utica, N. Y.; the Young Men's Association, Buffalo, N. Y.; the Baltimore & Ohio Railroad Co., Baltimore, Md.; John Heisely, Esq., Harrisburgh, Pa.; Col. J. Ross Snowden, U. S. Mint, and Prof. John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer read his statement of the receipts and payments for the month of March.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (11) were proposed, and the candidates proposed at the last meeting (9) duly elected.

Abstract of Meteorological Observations for February, 1860; made in Philadelphia, Adams, Franklin, and Somerset Counties,

Abstract of Meteorological Observations for February, 1860; made in Philadelphia, Adams, Franklin, and Somerset Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.

	PHILADELPHIA.—Lat. 39° 57′ 28″ N. Long. 75° 10′ 28″ W. Height above the sea 50 feet. Prof. J. A. KIRKPATRICK, Observer.								GETTYSBURG, Adams Co. Lat. 39° 49′ N. Long. 77° 18′ W. Height 624 ft. Prof. M. JACOBS, Obs					CHAMBERSBURG, Franklin Co. Lat. 39° 58′ N. Long. 77° 45′ W. Height 618 ft. Wm Heyser, Jr., Obs					SOMERSET, Somerset Co. Lat. 40° N. Long. 79° 3′ W. Height 2195 feet. GEO. MOWRY, Observer.						
1860.	Barom	Thermometer.			Force of vapor.	Relative humidity.	Rain and Snow.	Prevail'g winds.	Barom	Thermom.		Rain and Snow.	Prevail'g winds.	Barom	Thermom.		Rain and Snow.	Prevail'g winds.	Barom	Thermom.		Force of vapor.	Relative humidity.	Rain and Snow.	Prevail'g winds.
Feb.	Mean.	Mean.	Daily oscillation	Mean daily range.	2 P.M.	2 P.M.			Mean.	Mean.	Mean daily range.			Mean	Mean.	Mean daily range.			Mean.	Mean.	Mean daily range.	2 P.M.	2 P.M.		
	Inch.	°	°	°	Inch.	Per ct.	Inches.	Direc.	Inch.	°	°	Inch.	Direc.	Inch	°		Inch.	Direc.	Inch.	°	°	Inch.	Per ct.	Inch.	Direc.
1	30·121	10·7	23	28·7	·036	44		N W.	29·780	7·0	27·3	0·100	(var.)	29·619	11·7			W.	27·819	6·3	23·3	·040	52		(var.)
2	30·313	9·2	14	3·2	·038	45		N W.	29·948	4·3	6·7		S W.	29·767	11·0	3·3		W.	27·873	12·0	7·0	·135	100		W.
3	30·271	13·8	19	4·7	·055	53		N NW.	29·900	6·7	12·3		S W.	29·715	11·7	8·0		W.	27·856	13·0	4·3	·056	78		S E.
4	30·238	24·3	18	10·5	·093	56		N NW.	29·856	19·0	12·3		(var.)	29·682	25·3	11·7		W.	27·826	31·0	18·0	·186	67		S W.
5	30·195	29·7	21	5·3	·138	70		N N E.	29·780	24·7	7·0	0·385	(var.)	29·588	27·0	4·3	0·200	W.	27·742	28·7	7·0	·167	100	0·057	S.
○ 6	29·687	45·8	17	16·2	·308	89	0·195	(var.)	29·286	37·0	10·7		(var.)	29·108	38·7	11·7		W.	27·452	43·0	14·3	·317	96		(var.)
7	29·816	42·2	13	3·7	·146	44		N W.	29·448	34·3	2·3		N W.	29·336	35·7	3·0		W.	27·578	31·0	12·0	·165	72		W.
8	29·865	34·3	11	7·8	·129	54		N.	29·482	27·7	6·7		(var.)	29·317	29·7	6·0		W.	27·593	26·7	5·0	·110	49		N E.
9	29·661	38·5	22	5·5	·146	44		S S W.	29·229	36·7	9·7		(var.)	29·065	38·3	9·3		W.	27·467	35·7	9·0	·201	62		W S W.
10	29·880	23·3	19	15·2	·071	50		N W.	29·596	17·7	19·0		N W.	29·483	20·7	17·3		W.	27·754	13·0	22·7	·063	67		N W.
11	29·899	20·7	13	2·7	·076	56	0·052	S E.	29·438	22·3	5·3		(var.)	29·255	25·7	5·7		W.	27·466	22·3	9·3	·153	94	0·145	(var.)
12	30·000	28·0	12	7·3	·106	58		N W.	29·673	29·0	3·7		N E.	29·474	25·7	3·3		W.	27·749	22·3	1·3	·140	78		(var.)
◐ 13	29·886	38·0	21	10·0	·137	48		S W.	29·475	37·7	11·7		S.	29·300	41·7	14·0	0·100	(var.)	27·607	42·3	20·0	·182	47	0·225	W S W.
14	29·903	41·2	12	8·5	·162	58		(var.)	29·434	45·7	8·7		(var.)	29·349	44·0	11·7	1·600	W.	27·619	37·0	8·0	·168	65		(var.)
15	29·801	30·2	11	11·0	·155	89	0·943	E N E.	29·362	26·7	19·0	0·675	N E.	29·205	28·7	15·3		E.	27·390	29·7	7·3	·174	100	0·463	S E.
16	29·694	28·8	17	3·7	·113	57		(var.)	29·323	18·7	8·0		(var.)	29·151	22·3	6·3		W.	27·406	20·3	9·3	·066	47		W.
17	29·881	17·5	12	11·3	·068	57		N W.	29·482	11·7	7·0		W.	29·308	20·0	2·3		E.	27·493	19·3	9·0	·153	88		(var.)
18	29·372	24·8	21	7·3	·174	94	1·150	N E.	28·875	21·7	10·0	0·600	N N E.	28·689	22·7	6·7	1·000	(var.)	26·985	25·7	6·3	·169	84	0·202	S.
19	29·678	23·0	10	4·5	·076	52		N W.	29·377	17·7	4·0		W N W	29·213	20·7	4·7		W.	27·508	13·7	12·0	·085	72		W.
20	30·010	28·0	22	7·3	·125	65		S W.	29·641	14·0	1·0		S.	29·435	24·0	10·0		W.	27·689	33·0	19·3	·169	54		S W.
● 21	30·076	40·7	21	12·7	·210	63		S W.	29·736	31·7	17·7		S.	29·505	36·3	12·3		(var.)	27·730	44·0	11·0	·204	45		S E.
22	29·772	50·7	20	10·0	·417	97	0·337	S E.	29·242	44·3	12·7	0·615	S S W.	29·093	44·7	9·7	0·770	E.	27·369	54·7	10·7	·406	74	0·170	S.
23	29·591	56·5	23	9·5	·380	52	0·010	S W.	29·183	50·7	6·3		W.	29·040	47·3	6·7		W.	27·417	46·0	9·3	·219	54		W.
24	29·721	43·3	20	9·8	·218	58	0·037	(var.)	29·379	38·7	12·0		N W.	29·228	38·3	10·7		W.	27·538	32·3	13·3	·152	64		W.
25			18		·102	40		N W.	29·623	29·7	9·0		W S W.	29·465	31·0	7·3		W.	27·696	27·0	5·3	·161	89		W.
26	30·252	35·3	18		·096	35		S W.	29·882	30·3	6·7		S W.	29·708	32·7	5·0		W.	27·906	31·7	7·0	·146	57		S W.
27	30·262	44·2	25	8·8	·207	47		S S W.	29·855	41·0	10·7		S.	29·686	43·0	10·3		W.	27·907	46·7	15·3	·308	64		(var.)
28			21					S W.	29·864	46·7	5·7		S.	29·684	46·7	3·7		W.	27·935	49·3	2·7	·302	62		S.
☽ 29	30·108	50·3	21		·320	69		N E.	29·817	50·3	4·3	0·250	S.	29·553	50·7	6·7		E.	27·791	50·3	2·3	·378	81	0·409	S.
Means	29·924	32·3	18	8·8	·154	59	2·724	N 62° W.	29·544	28·4	9·9	2·625	S 74° W.	29·380	30·5	8·1	3·670	N 88° W.	27·625	30·7	10·4	·180	71	1·671	S 53° W.